Pinnacle™ Plus+ 10 kW (325–800 Vdc)

AE Bus, 15 V User, Master/ Slave, Sync Pulse

March 2005 5702285-B

User Manual

User Manual

Pinnacle™ Plus+ 10 kW

5702285-B

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WARNING:

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Safety and Product Compliance Guidelines

This manual documents how to install operate, maintain, and troubleshoot the Advanced Energy® Apex generator power supply. Retain this manual for future reference.

IMPORTANT SAFETY INFORMATION

To ensure safe installation and operation of the Advanced Energy® Apex generator, read and understand this manual before attempting to install and operate this unit. At a minimum, read and follow the safety instructions and practices documented under "Safety Guidelines" on page 1-2.

INTERPRETING THE MANUAL

The following sections explain the document type conventions and the danger, warning, and caution boxes that provide information about the specific levels of hazard seriousness.

Type Conventions

Please note the following type conventions:

- Pin and signal names appear in capitalized italics (*POWER_ON*).
- New terms appear in italicized text.
- Unit labels (switches, indicators, and so on) appear in boldface text (**MODIFY**).
- Commands (**162**) and command names (**set point**) appear in boldface, lowercase text.

Danger, Warning, and Caution Boxes

This symbol represents important notes concerning potential harm to people, this unit, or associated equipment. Advanced Energy® includes this symbol in Danger, Warning, and Caution boxes to identify specific levels of hazard seriousness.

DANGER:

DANGER indicates an imminently hazardous situation that, if not avoided, will result in death or serious injury. DANGER is limited to the most extreme situations.

WARNING:

WARNING indicates a potentially hazardous situation that, if not avoided, could result in death or serious injury, and/or property damage.

CAUTION:

CAUTION indicates a potentially hazardous situation that, if not avoided, could result in minor or moderate injury, and/or damage to property. CAUTION is also used for property-damage-only accidents.

SAFETY GUIDELINES

Review the following information before attempting to install and operate the product.

Rules for Safe Installation and Operation

Please note the following rules:

- Do not attempt to install or operate this equipment without proper training.
- Ensure that this unit is properly grounded (see also “Grounding” on page 5-4).
- Ensure that all cables are properly connected (see “Installation” on page 5-1).
- Verify that input line voltage and current capacity are within specifications before turning on the power supplies (see “Electrical Specifications” on page 3-4).
- Use proper electrostatic discharge (ESD) precautions.

- Always be careful around this equipment.

Interpreting Product Labels

The following labels may appear on your unit:

2911

The product warranty is void if you remove the power supply box cover.

Contact AE Global Customer Support for more information (see "AE Global Customer Support" on page 7-19).

1020

CE label

1069

Earth ground

WARNING
HAZARDOUS VOLTAGE
Risk of death or bodily injury.
Disconnect all sources of input
power before working on this
unit or anything connected to it.

1332

Hazardous voltage

1028

High voltage

1309

Hot surface

1030

Nonionizing radiation

1154

NRTL

1029

Protective Earth ground

1027

Refer to manual for more information

1024

Short circuit protected

PRODUCT COMPLIANCE

The following sections include information about unit compliance and certification, including the conditions of use required to be in compliance with the standards and directives.

Product Certification

Certain options of this product are certified by:

- CE marking, self addressed by AE Compliance Engineering
- EMC measurements, verified by an independent third-party EMC testing laboratory.

For more information, refer to the letter of conformance (US) or declaration of conformity (EU) accompanying the product.

Safety and Compliance Directives and Standards

Certain options of this unit have been tested for and comply with the following safety and electromagnetic compatibility (EMC) directives and standards and semiconductor industry guidelines.

Note: This device must be installed and used only in compliance with the directives and standards listed in addition to VDE 0113, EN 60204 (IEC 60204), and applicable requirements.

Note: Any unauthorized expansion, repair, modification, or misuse of this product violates any compliance or certification associated with the product. In this situation, you are responsible to guarantee the compliance of the product.

ELECTROMAGNETIC COMPATIBILITY (EMC) DIRECTIVES AND STANDARDS

Table 1-1. *Electromagnetic Compatibility (EMC) Directives*

Directive	Description
89/336/EEC	EC Council directive on the approximation of the laws of the Member States relating to electromagnetic compatibility (EMC Directive)

Table 1-2. *Electromagnetic Compatibility (EMC) Standards*

Standards	Description
47 CFR Part 18	Code of Federal Regulations—Limits and methods of measurement of radio interference characteristics of industrial, scientific, and medical equipment
EN 55011	Limits and methods of measurement of radio disturbance characteristics of industrial, scientific, and medical (ISM) radio frequency equipment (Class A, Group 2)(CISPR 11)
EN 61000-6-2	Electromagnetic Compatibility (generic immunity sstandard—industrial

SAFETY DIRECTIVES AND STANDARDS

Table 1-3. *Safety Directives*

Directive	Description
73/23/EEC	EC Council directive on the harmonization of the laws of the Member States relating to electrical equipment designed for use within certain voltage limits (LVD – Low Voltage Directive)

Table 1-4. *Safety Standards*

Standards	Description
EN 50178	Electronic equipment for use in electrical power installations

Installation Requirements

Install this unit according to the following requirements.

⚠ WARNING:
Operating and maintenance personnel must receive proper training before installing, troubleshooting, or maintaining high-energy electrical equipment. Potentially lethal voltages could cause death, serious personal injury, or damage to the equipment. Ensure that all appropriate safety precautions are taken.

⚠ DANGER:
RISK OF DEATH OR BODILY INJURY. Disconnect all sources of input power before working on this unit or anything connected to it.

Conditions of Use

To comply with the stated directives and standards, you must meet the following conditions of use:

- Before making any other connection to this device, connect the supplemental Protective Earth (ground) terminal to an earth (ground) terminal with a copper wire that is sized according to the applicable requirements.

- For delta-connected mains, primary and supplemental Protective Earth (ground) wires must be connected.
- Install and operate this device in an overvoltage category II installation only.
- Use only a shielded power cable on the output power connector.
- CE marked power supplies: install and operate this device only in a pollution degree 2 or better environment, which means an indoor location such as a computer room, office, or factory floor where only non-conductive pollution occurs during operation. Occasionally, condensation causes temporary conductivity when the device is not operating.
- Non-standard connectors for input and/or output power must be inaccessible to the operator.
- Advanced Energy Industries, Inc., may provide a supplementary protection circuit breaker in the power supply. You must provide a branch circuit backup fuse with a UL LISTED Type K5 or RK5 fuse or equivalent that is rated 15 A minimum and no more than four times full-load amps (not to exceed 125 A for 50 A or less rated breaker, and not to exceed 175 A for 51 through 100 A rated breaker).

  Note: See "Electrical Specifications" on page 3-4 for more information about the electrical specifications of your power supply.

- If your unit does not have a circuit breaker, install and operate it with an AE-approved circuit breaker on the AC input to provide the required over-current protection. In addition, you must provide the primary circuit protection (such as the branch circuit backup fuse).

Theory

GENERAL DESCRIPTION

The Advanced Energy Pinnacle Plus+ series of DC power supplies provide the ultimate advantages in DC power.

They...

- Are light and compact
- Are highly efficient (low internal heat dissipation)
- Provide excellent regulation and stability
- Have a highly reliable solid state design
- Store very little energy in the output filter
- Quickly extinguish and recover from arcs
- Deliver full power over a 4:1 impedance range (with no taps)
- Provide a very high power factor

Output Impedance Range

No taps, mechanical or electrical, exist in the Pinnacle Plus+ supply. The unit delivers full power over a 4:1 range of impedance without the need for tap changes. You never need to open the unit or generate signals to control taps.

Output Regulation

The Pinnacle Plus+ supply can be used as a power, current, or voltage source, depending on the method of output regulation selected. Since set point levels are stored in nonvolatile memory, you can use them to recover from input power interruptions and to ensure repeatability from run to run.

Interfaces

The Pinnacle Plus+ series of power supplies can be configured with a variety of interfaces. Your Pinnacle Plus+ supply can be controlled from an active front panel, the Pinnacle Remote Active Panel, an analog/digital connector (User port), or a serial communications (Host) port. The serial communications port, the active front panel,

and the Pinnacle Remote Panel provide access to all operating parameters and control functions. The User port provides limited access to operating parameters and control functions.

Microprocessor Advantages

The internal microprocessor checks for proper circuit operation while supervising all operating parameters. System diagnostics run when the unit is initially powered up. The most recent power settings and conditions (such as producing output) are retained in non-volatile memory.

Displays

The displays on the passive panels as well as the control panels show power, current, or voltage levels. (The displays show levels for unit A and unit B if this is a dual unit.) They also display information about output, pulsing, set point, interlock, bus fault, overtemp, arcs, and error codes.

Arc-suppression Feature

The Pinnacle Plus+ supply's arc-handling feature ensures the shortest arc recovery time in the industry. You can implement user-defined arc-handling functions during your normal process cycle. Parameters, including hard arc count limit, voltage trip level, enable, and disable, are selectable through the unit's active control panel (optional), Pinnacle Remote Active Panel, or a serial (Host) communications port.

THEORY OF OPERATION

The Pinnacle Plus+ power supply is a sophisticated and intelligent DC pulse power supply designed exclusively for use in vacuum environments. Figure 2-1 on page 2-2 and the following paragraphs outline the theory of operation.

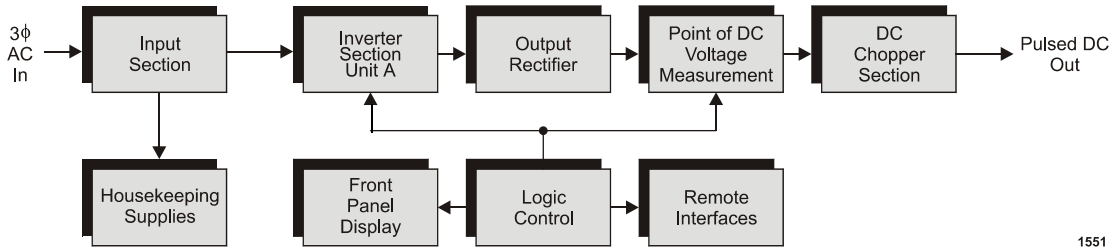

Figure 2-1. *Pinnacle™ Plus+ functional block diagram.*

Input

In the input section, AC line voltage is applied through the circuit breaker to a three-phase contactor. The contactor, when closed, delivers the line voltage to a rectifier bridge, where it is converted to DC. This bus provides DC voltage to the inverter section. The input section also provides power to the housekeeping section.

Housekeeping Supply

The housekeeping supply section provides low voltage to power the electronic circuits within the Pinnacle Plus+ unit.

Inverter

The inverter section converts DC to high-frequency voltage by alternating the current through switching transistors.

Output

In the output section, an isolation transformer steps up the high-frequency voltage from the inverter section and sends it to a full-wave rectifier bridge.

Output Measurement

The output measurement section measures current, and voltage. These signals are typically scaled to 0 to 10 VDC and sent to the logic, control, and interfaces.

DC Chopper Section

This section uses a patented circuit with a tapped inductor and a shunt switch to chop or pulse the DC before being sent to the output.

Logic Control

The microprocessor in the logic control section uses operator-supplied parameters and set points to control the output. This section is also responsible for providing status information to the operator through all interfaces and for controlling the input section.

Remote Interfaces

The Pinnacle Plus+ unit supports four types of interfaces: a User port (Analog/ Digital), a serial (Host) port (RS-232/422/485), an active front panel, and a Pinnacle Remote Panel interface. All four interfaces communicate operator-supplied inputs to the logic control section and provide the operator with status information.

Specifications

FUNCTIONAL SPECIFICATIONS

Table 3-1. *Functional Specifications*

Modes of Control	Serial communications (Host) port, User port (analog/digital interface), active front panel, and/or Pinnacle Remote Active Panel
Passive Panel Options	Your unit also may feature either a passive front panel, remote active panel, blank panel, or an active front panel.
Method of Output Regulation	The regulation mode is the parameter that remains constant when the Pinnacle Plus+ is producing output; it can be power, or current, or voltage. Select one of these regulation modes from the optional Pinnacle Remote Active Panel, the active front panel, the User port, or the serial (Host) port. *Note:* Output power must be off (that is, output must be deenergized) to switch between regulation modes.
Programmable Set Points	You can program an output level (from low values up to the unit's maximum rate of output) for power, current, or voltage. You can also program the chopper output frequency and reverse time. Select these values from the optional Pinnacle Remote Active Panel, the active front panel, the User port, or the serial (Host) port. *Note:* The User port does not have access to the chopper.
Output Limits	You may set maximum output limits for power, voltage, and current. Select these values from the optional Pinnacle Remote Active Panel, the active front panel, or the serial (Host) port.
Process Control	You can control the process with the following features: joule mode, ramping, and recipes.

Table 3-1. *Functional Specifications (Continued)*

Process Monitoring	You can monitor process values for the following: target life timer, out-of-set point timer; over-voltage timer, and over-current timer.
Sync Pulse Functionality	You can control the synchronization of multiple independent units with the Pinnacle Plus+ Sync Pulse source controls. With this feature, multiple units may be synchronized at 0º. Additionally, units connected for Sync Pulse operation can share hard arcs.
Master/Slave Operation	By having your Pinnacle Plus+ supply reconfigured at the factory, the unit can become a building block in a master/slave system, thereby allowing Pinnacle Plus+ power installations of greater size than 10 kW.
Target Supervision	You can select one of eight target-life counters from the active front panel, Pinnacle Remote Active Panel, User port, or serial (Host) port. Target life can be monitored from the Pinnacle Remote Active Panel, the active front panel, and the serial port. *Note:* The User port has priority when selecting targets.
Arc Control	• You can monitor micro arc density and hard arc density from the Pinnacle Remote Panel, the active front panel, and the serial (Host) port. • You can change arc trip level voltage. You can enable or disable micro arc handling but hard arc handling is always enabled. • Monitoring options include: arc count per second and arc count per run. Additionally, you can have the unit indicate when a set number of hard arcs have occurred in the process run.
Arc Energy	200 µJ/ kW with micro arc handling active.

Table 3-1. *Functional Specifications (Continued)*

Cooling	Air-cooled
Fault Conditions	Several fault conditions will either cause the Pinnacle Plus+ supply to shut off output or prevent output from being turned on. These conditions include open interlock loops, input power failure, over-temperature, and user-controlled timers.

PHYSICAL SPECIFICATIONS

Table 3-2. *Physical Specifications*

Size	133 mm (H) x 483 mm (W) x 639 mm (D), including connectors (5.22 in (H) x 19 in (W) x 25.18 in (D))
Weight	30 kg (66 lb)
Output Connector	Two terminal, multi-contact, pluggable connector or UHF connector
Output Power Cable	For optimal performance, it is recommended that you use an output power cable 3.05 m (10´) in length—or shorter. *Note:* The output power cable must *not* exceed 10 m (32.8´) or you may damage your power supply.
Input Power Connector	Five terminal, DIN compression terminal block. Maximum wire size #6AWG
User Port Connector	Please reference the “I/O Communication and Control” chapter.
Serial (Host) Port Connector	Please reference the “I/O Communication and Control” chapter.

ELECTRICAL SPECIFICATIONS

Table 3-3. *Electrical Specifications*

208 VAC Input Voltage **(wye or delta connection)**	180 to 229 VAC, 3-phase, 4-wire, 50 to 60 Hz, no neutral required. Leakage current less than 3.5 mA. Maximum phase to phase voltage: 208 V + 10% Maximum phase to ground/chassis voltage: 250 V **⚠ DANGER:** **RISK OF DEATH OR BODILY INJURY: For delta connections, considerably more leakage current will exist. You must connect the primary and supplemental Protective Earth (ground) wires.**
208 VAC Input Current	35 A nominal per phase, at least 90% EFF; 50 A circuit breaker
400 VAC Input Voltage **(wye connection only)**	360 to 440 VAC, 3-phase, 4-wire, 50 to 60 Hz, no neutral required. Leakage current less than 3.5 mA. Maximum phase to phase voltage: 400 V +10% Maximum phase to ground/chassis voltage: 230 V ± 10%
400 VAC Input Current	17 A nominal per phase, at least 90% EFF; 20 A circuit breaker
480 VAC Input Voltage **(wye connection only)**	Not available for this configuration
480 VAC Input Current	Not available for this configuration

Table 3-3. *Electrical Specifications (Continued)*

Output Accuracy	Accuracy of actual output value to set point at 25ºC is ±1% of the actual value (V, kW, or A) or ±0.2% of the full rated output (whichever is greater) for the full input voltage range and within the output impedance range
Load Regulation	±1% for 4:1 load change within V-I limits of tap
Line Regulation	±1% for 10% line voltage change or ±2% frequency change
Repeatability	Output power repeatability from run to run at a constant set point is 0.1% from 10% to 100% of rated power.
Temperature Coefficient	<0.015%/°C (<150 ppm/°C) variation in the regulated output parameter over 20°C to 40°C ambient temperature range
Output Ripple Voltage (360 Hz / 300 Hz)	The component of output voltage ripple as related to input line frequency is less than 2% rms.
Accuracy of All Analog Signals	±1% of the actual value (V, kW, or A) or ±0.2% of the full scale value, whichever is greater
Power Factor	> 0.95 for 10 kW
Standard Output Range (full power)	10 kW over the 325-to-800-Vdc range in DC mode, with a maximum current of 30.8 A *Note:* Output is measured at the DC inverter output (see Figure 2-1 on page 2-2). *Note:* Do *not* use an output cable longer than 32.8 feet (10 m).
Usable Output Range	See Figure 3-3 on page 3-15.
Impedance Range	See Figure 3-4 on page 3-15.
Accuracy of User-defined Limits	
Current	0 to 5% over the limit from 10 to 100% of full rated output
Voltage	0 to 5% over the limit from 10 to 100% of full rated output
Power	0 to 10% over the limit from 2 kW to 10 kW

Table 3-3. *Electrical Specifications (Continued)*

Ignition Capability	Voltage clamped to 1700 V at 50 mA maximum Ignition cycle runs at 1400 V for 100 ms, then at the user-selected maximum output voltage limit for 900 ms.
Analog Interface Scaling	Depending on the choice and configuration of your User port, the analog input and output signals will be either 0 to 5 V or 0 to 10 V full scale. If your supply does not contain a User port that emulates another supply, full scale for set point input and readback output is as follows: for power, 0 to 10 kW; for current, 0 to 40 A; for voltage, 0 to 1500 V.
Output Polarities	The two terminal connection allows a floating output. The maximum voltage at either terminal relative to ground should not exceed 1700 V (peak).
Output Frequency (self-run)	5 kHz to 350 kHz, 5 kHz increments *Note:* The PNCL PLUS+ self-run frequency has a granularity of 50 ns. Therefore, the maximum difference from set point-to-actual is always <1% (never exceeding ± 2.6 kHz) maximum, with an average difference across the frequency range of <0.1%.
Reverse Time	0.4 µs to 5.0 µs, 0.1 µs increments, up to a 45% reverse duty cycle for a given frequency See "Maximum Allowable Reverse Time For a Given Frequency" on page 3-6 and "Frequency and Reverse Time Settings" on page 6-3 for more information.
Reverse Voltage	Approximately 10% of the operating voltage (voltage readback shown on the active front panel interface).

Maximum Allowable Reverse Time For a Given Frequency

Note: Frequency is limited to 150 kHz when the pulsing enabled mode is set to be enabled always.

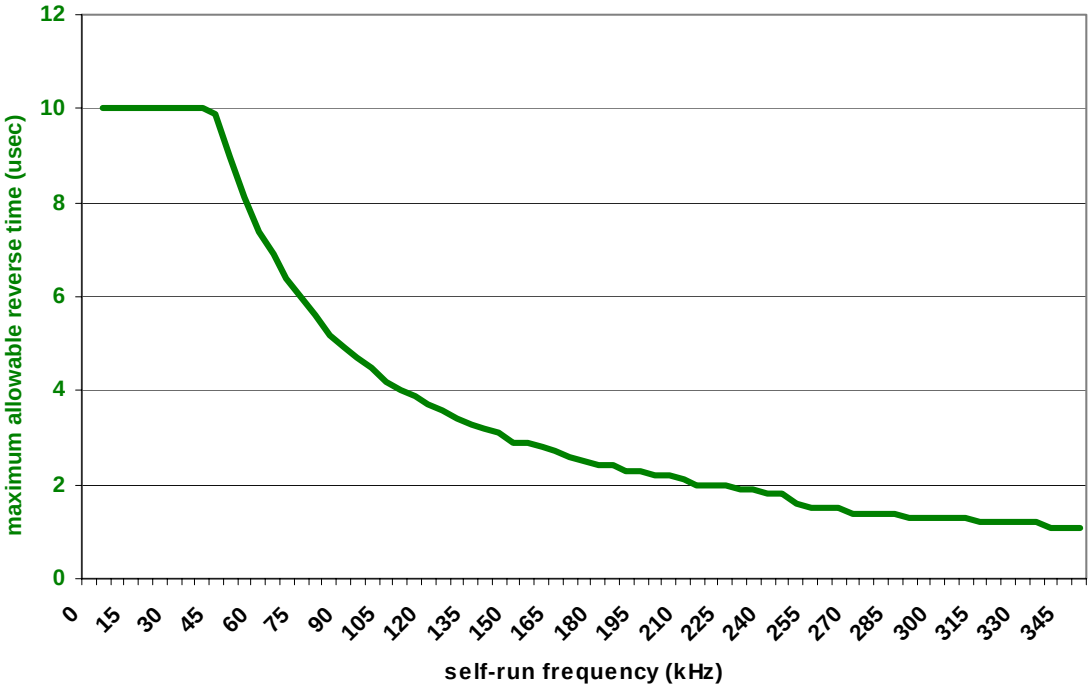

Figure 3-1. *Pulse reversal times and self-run frequencies*

Table 3-4. *Reverse Time Given a Self-Run Frequency*

Requested Frequency (kHz)	Actual Frequency (kHz)	Pulse Reversal Time Maximum (µs)	Duty Cycle (min%) Reverse/ Period	Duty Cycle (max%) Reverse/ Period
5	5	10	0.20	5.0
10	10	10	0.40	10.0
15	15.004	10	0.60	15.0
20	20	10	0.80	20.0
25	25	10	1.00	25.0
30	29.985	10	1.20	30.0
35	35.026	10	1.40	35.0
40	40	10	1.60	40.0
45	45.045	9.9	1.80	44.6

Table 3-4. *Reverse Time Given a Self-Run Frequency (Continued)*

Requested Frequency (kHz)	Actual Frequency (kHz)	Pulse Reversal Time Maximum (µs)	Duty Cycle (min%) Reverse/ Period	Duty Cycle (max%) Reverse/ Period
50	50	9.0	2.00	45.0
55	54.945	8.1	2.20	44.5
60	60.06	7.4	2.40	44.4
65	64.935	6.9	2.60	44.8
70	69.93	6.4	2.80	44.8
75	74.906	6.0	3.00	44.9
80	80	5.6	3.20	44.8
85	85.106	5.2	3.40	44.3
90	90.09	4.9	3.60	44.1
95	94.787	4.7	3.79	44.5
100	100	4.5	4.00	45
105	105.263	4.2	4.21	44.2
110	109.89	4	4.40	44
115	114.943	3.9	4.60	44.8
120	119.76	3.7	4.79	44.3
125	125	3.6	5.00	45
130	129.87	3.4	5.19	44.2
135	135.135	3.3	5.41	44.6
140	139.86	3.2	5.59	44.8
145	144.928	3.1	5.80	44.9
150	150.376	2.9	6.02	43.6
155	155.039	2.9	6.20	45
160	160	2.8	6.4	44.8
165	165.289	2.7	6.61	44.6
170	169.492	2.6	6.78	44.1
175	175.439	2.5	7.02	43.9

Table 3-4. *Reverse Time Given a Self-Run Frequency (Continued)*

Requested Frequency (kHz)	Actual Frequency (kHz)	Pulse Reversal Time Maximum (µs)	Duty Cycle (min%) Reverse/ Period	Duty Cycle (max%) Reverse/ Period
180	180.18	2.4	7.21	43.2
185	183.486	2.4	7.41	44
190	190.476	2.3	7.62	43.8
195	194.175	2.3	7.77	44.7
200	200	2.2	8	44
205	204.082	2.2	8.16	44.9
210	210.526	2.1	8.42	44.2
215	215.054	2	8.6	43
220	219.78	2	8.79	44
225	224.719	2	8.99	44.9
230	229.885	1.9	9.2	43.7
235	235.294	1.9	9.41	44.7
240	240.964	1.8	9.64	43.4
245	243.902	1.8	9.76	43.9
250	250	1.6	10	40
255	256.41	1.5	10.26	38.5
260	259.74	1.5	10.39	39
265	266.667	1.5	10.67	40
270	270.27	1.4	10.81	37.8
275	273.973	1.4	10.96	38.4
280	281.69	1.4	11.27	39.4
285	285.714	1.4	11.43	40
290	289.855	1.3	11.59	37.7
295	294.118	1.3	11.76	38.2
300	298.507	1.3	11.94	38.8
305	303.03	1.3	12.12	39.4

Table 3-4. *Reverse Time Given a Self-Run Frequency (Continued)*

Requested Frequency (kHz)	Actual Frequency (kHz)	Pulse Reversal Time Maximum (µs)	Duty Cycle (min%) Reverse/ Period	Duty Cycle (max%) Reverse/ Period
310	307.692	1.3	12.31	40
315	312.5	1.2	12.50	37.5
320	317.46	1.2	12.70	38.1
325	322.581	1.2	12.90	38.7
330	327.869	1.2	13.11	39.3
335	333.333	1.2	13.33	40
340	338.983	1.1	13.56	37.3
345	344.828	1.1	13.79	37.9
350	350.877	1.1	14.04	38.6

Reverse Time As A Function of Voltage Limit

Note: Not all Pinnacle Plus+ units are shipped with reverse time as a function of voltage limit. This is a special feature that your power supply must be configured for at the factory.

Some processes require that the Pinnacle Plus+ power supply allow a longer duration when reversing the voltage. By utilizing the V-Limit function of your power supply, you may be able to increase the reverse time to a maximum of 10 µs (when voltage is limited to 325 V). When the unit is set for 650 V (or higher in Hi-Z models), the maximum reverse time is 5 µs. As you decrease process voltage using the V-Limit function, the reverse time increases linearly until it reaches the maximum allowable value of 10 µs.

Note: The maximum reverse time duty cycle is still 45%.

Figure 3-2 on page 3-11 is a graph of pulse reversal times as a function of the user voltage limit. Table 3-5 on page 3-11 provides a detailed list of reverse times and the corresponding user voltage limit.

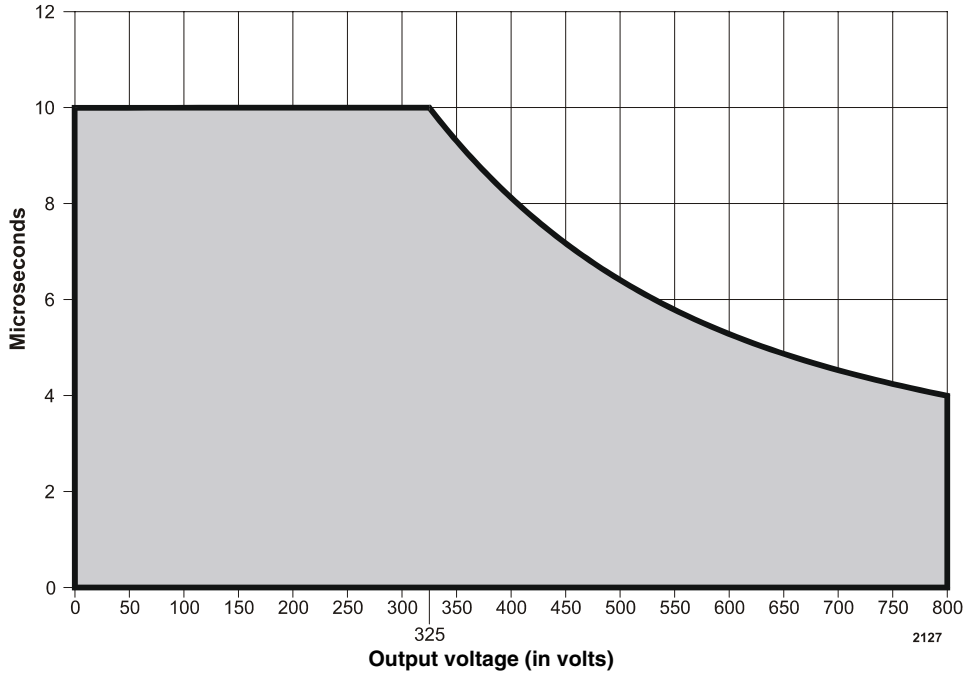

Figure 3-2. *Pulse reversal time as a function of voltage limit (V-Limit)*

Table 3-5. *Reverse Time as a Function of Voltage Limit (V-Limit)*

V-Limit (in Volts)	Corresponding Reverse Time
0 to 325	10 µs
330	9.8 µs
335	9.7 µs
340	9.5 µs
345	9.4 µs
350	9.2 µs
355	9.1 µs
360	9 µs
365	8.9 µs
370	8.7 µs
375	8.6 µs
380	8.5 µs
385	8.4 µs

Table 3-5. *Reverse Time as a Function of Voltage Limit (V-Limit)*

V-Limit (in Volts)	Corresponding Reverse Time
390	8.3 µs
395	8.2 µs
400	8.1 µs
405	8 µs
410	7.9 µs
415	7.8 µs
420	7.7 µs
425	7.6 µs
430	7.5 µs
435	7.4 µs
440	7.3 µs
445	7.3 µs
450	7.2 µs
455	7.1 µs
460	7 µs
465	6.9 µs
470	6.9 µs
475	6.8 µs
480	6.7 µs
485	6.7 µs
490	6.6 µs
495	6.5 µs
500	6.5 µs
505	6.4 µs
510	6.3 µs
515	6.3 µs
520	6.2 µs
525	6.1 µs
530	6.1 µs
535	6 µs
540	6 µs
545	5.9 µs
550	5.9 µs

Table 3-5. *Reverse Time as a Function of Voltage Limit (V-Limit)*

V-Limit (in Volts)	Corresponding Reverse Time
555	5.8 µs
560	5.8 µs
565	5.7 µs
570	5.7 µs
575	5.6 µs
580	5.6 µs
585	5.5 µs
590	5.5 µs
595	5.4 µs
600	5.4 µs
605	5.3 µs
610	5.3 µs
615	5.2 µs
620	5.2 µs
625	5.2 µs
630	5.1 µs
635	5.1 µs
640	5 µs
645	5 µs
650	5 µs
655	4.9 µs
660	4.9 µs
665	4.8 µs
670	4.8 µs
675	4.8 µs
680	4.7 µs
685	4.7 µs
690	4.7 µs
695	4.6 µs
700	4.6 µs
705	4.6 µs
710	4.5 µs
715	4.5 µs

Table 3-5. *Reverse Time as a Function of Voltage Limit (V-Limit)*

V-Limit (in Volts)	Corresponding Reverse Time
720	4.5 µs
725	4.4 µs
730	4.4 µs
735	4.4 µs
740	4.3 µs
745	4.3 µs
750	4.3 µs
755	4.3 µs
760	4.2 µs
765	4.2 µs
770	4.2 µs
775	4.1 µs
780	4.1 µs
785	4.1 µs
790	4.1 µs
795	4 µs
800	4 µs

Operating and Impedance Range Illustrations

The following graphs illustrate the output power operation range and output impedance range for your Pinnacle Plus+ power supply.

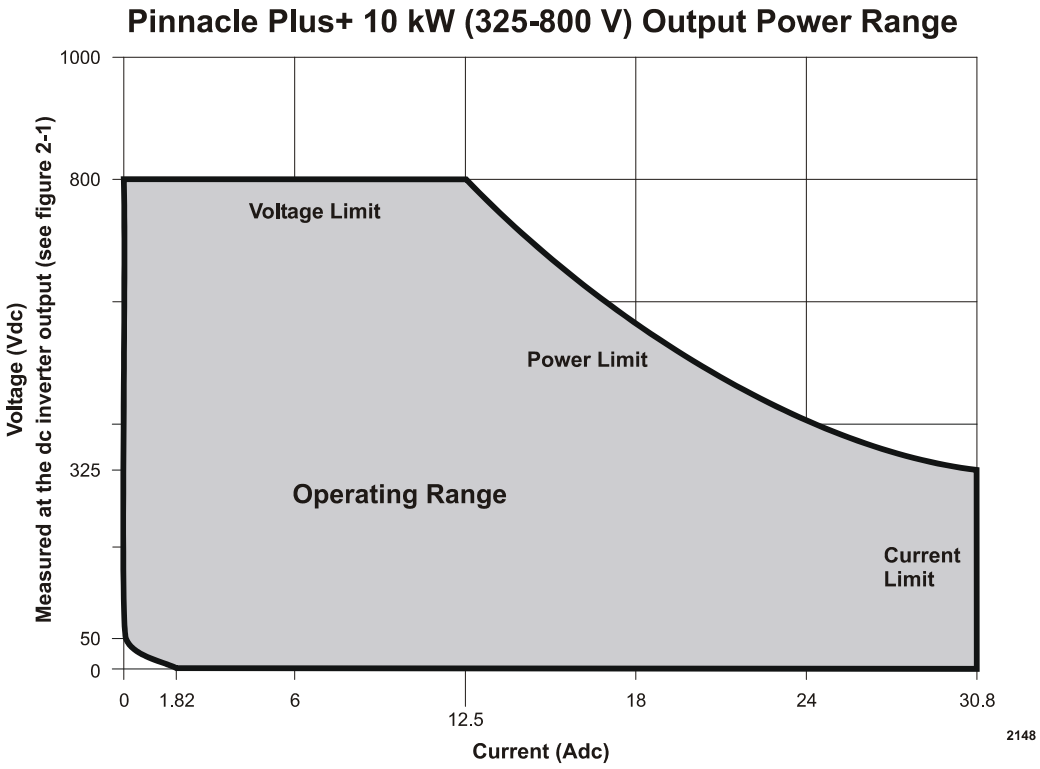

Figure 3-3. *Operating range*

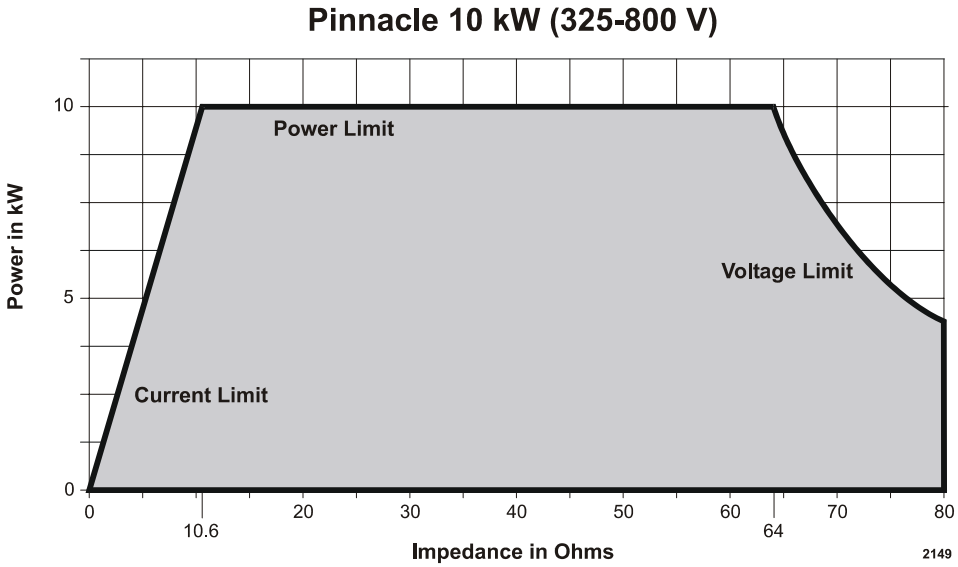

Figure 3-4. *Impedance range*

ENVIRONMENTAL SPECIFICATIONS

Table 3-6. *Climatic Specifications*

	Temperature	Relative Humidity	Air Pressure
Operating	Class 3K3 +5°C to +40°C +41°F to +104°F	Class 3K3 5% to 85% (Note 1) +1 g/m^3 to +25 g/m^3	Class 3K3 (or more severe) 80 kPa to 106 kPa 800 mbar to 1060 mbar (approximately 2000 m above sea level)
Storage	Class 1K4 -25°C to +55°C -13°F to +131°F	Class 3K3 5% to 85% +1 g/m^3 to +25 g/m^3	Class 3K3 (or more severe) 80 kPa to 106 kPa 800 mbar to 1060 mbar (approximately 2000 m above sea level)
Transportation	Class 2K3 -25°C to +70°C -13°F to +158°F	Class 2K3 95% (Note 2) +60 g/m^3 (Note 3)	Class 2K3 (or more severe) 66 kPa to 106 kPa 660 mbar to 1060 mbar (approximately 3265 m above sea level)

Note 1 Non-condensing

Note 2 Maximum relative humidity when the unit temperature slowly increases, or when the unit temperature directly increases from -25°C to +30°C

Note 3 Maximum absolute humidity when the unit temperature directly decreases from +70°C to +15°C

COOLANT SPECIFICATIONS

Table 3-7. *Coolant Specifications*

Coolant Temperature	Air (gas) minimum 0°C, maximum 40°C *Note:* (See "Cooling Requirements" on page 5-2 for more information.)
Pollution Degree	CE Marked devices: install and operate this device in a pollution degree 2 or better environment, which means an indoor location such as a computer room, office, or factory floor where only non-conductive pollution occurs during operation. Occasionally, condensation causes temporary conductivity when the device is not operating.
EMI/EMC	Tested for electromagnetic compatibility. *Note:* See the "Safety/Compliance" section of the "Introduction" chapter and the declaring letter for specific standards.
Acoustic Noise	Noise generated by this unit is 71.5 dB (A) at a 1 m distance

I/O Communication and Control

USER PORT

The User port (analog/ digital interface) is a 15 V isolated or non-isolated interface card with a 37-pin, subminiature-D, female connector. This interface emulates the MDX User port and a subset of the MDXII User port.

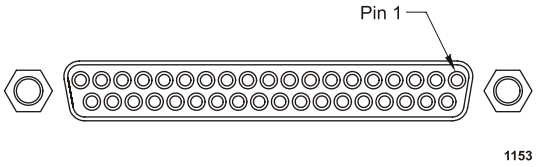

Figure 4-1. *37-pin subminiature-D female connector*

Installation

DANGER:

Disconnect all sources of input power before working on this unit or anything connected to it.

Note: Signals at the User port can be sensitive to noise. We recommend that you take standard preventative measures against electro-magnetic interference (EMI), including using shielded cabling on the User port.

Note: Turn off ac input power to the Pinnacle Plus+ unit before connecting a cable to the user port connector. Note that we recommend taking standard preventative measures against electro-static discharge (ESD) around all Pinnacle Plus+ units.

Note: Grounding the User port at the power supply reduces noise interference. To avoid ground loop problems, you should typically ground only one end.

If you have a remote panel and you want to operate the Pinnacle Plus+ supply from the User port, you must set the control mode for User on the Pinnacle Active Remote Panel. See the "Main Menu" section in the "Display and Standard Serial Controls" chapter of this manual.

Signals

The following paragraphs give general information about the User port's analog and digital signals. The subsequent table provides information about each pin.

ANALOG SIGNALS

A ".A" suffix appended to a pin name indicates an analog signal. Analog common lines are denoted by the "COM.A" suffix.

You can configure your unit's analog signals to be either 5 V or 10 V (full-scale) via three jumpers. The following lists indicate where you must place the jumpers to achieve either a 0 to 5 V scaling or a 0 to 10 V scaling.

DANGER:

Power down the Pinnacle Plus+ unit and take proper ESD precautions before removing the unit's top cover to position jumpers. Failing to power down the unit in this case could result in death or severe personal injury. Failing to take proper ESD precautions in this case could result in damage to the unit.

To provide for a 0 to 5V scaling:

- Place the P1 jumper (level-in signal) across pins 2 and 3.
- Place the P5 jumper (voltage, current, and power read-backs) across pins 1 and 2.
- Place the P4 jumper (level-out signal) across pins 1 and 2.

- Place the P3 jumper (*REF.A*) across pins 2 and 3.

To provide for a 0 to 10V scaling:

- Place the P1 jumper (level-in signal) across pins 1 and 2.
- Place the P5 jumper (voltage, current, and power readbacks) across pins 2 and 3.
- Place the P4 jumper (level-out signal) across pins 2 and 3.
- Place the P3 jumper (*REF.A*) across pins 1 and 2.

Analog outputs source or sink up to 3.0 mA and have an output impedance of 100 Ω. The input impedance of the analog input is 200kΩ.

DIGITAL SIGNALS

A ".D" suffix appended to the pin name indicates a digital signal. Digital commons are denoted by the "*COM.D*" suffix. Digital signals that are active when low are indicated with an overline on the pin name ($\overline{ARC.D}$).

Digital outputs are 0 to 15 V, are internally pulled up to 15 V through a 10 kΩ resistor, and have an output impedance of 100 Ω. When low, each digital output line will sink up to 35 mA.

Digital inputs are also 0 to 15 V, with a low input being less than 0.5 V. An open input defaults high via a 4.32 kΩ pull-up to 15 V. A low input will source up to 3.3 mA. All digital lines incorporate a low-pass filter that rejects signals less than 1 ms.

Pin-description Table

The User port has priority for selecting targets, even when the unit is in local or host control. Thus to select targets from the active front panel, the Pinnacle Active Remote Panel, or a host computer connected to the host port, you must set the target to 1 at the User port. Leaving the target bits open or leaving the User port pins unconnected causes the target selection at the User port to default to 1.

Table 4-1. *User Port Pin Descriptions*

Signal Pin	Return Pin	Pin Name	Signal Type	Description
1	**37**	*$\overline{CS1.D}$*	digital output	This signal, with pin 20 (*$\overline{CS2.D}$*), tells an external device (such as a cathode switch box) which of the Pinnacle Plus+ supply's target-life counters is active. See Table 4-2 on page 4-11 for more information.
2	**37**	*$\overline{OUTPUT.D}$*	digital output	This signal indicates that the contactor is closed and output power is on.
3	**37**	*$\overline{SETPOINT.D}$*	digital output	This signal indicates that the output is within specified tolerance of the requested set point.
4	**36**	*$\overline{TARGET0.D}$*	digital input	This signal is used with *$\overline{TARGET1.D}$* (pin 35) and *$\overline{TARGET2.D}$* (pin 34) to select the active target-life counter. See Table 4-3 on page 4-11 for more information.
5	**36**	*$\overline{IREG.D}$*	digital input	This signal is used with *$\overline{PREG.D}$* (pin 6) to set the regulation mode. See Table 4-4 on page 4-11 for more information.
6	**36**	*$\overline{PREG.D}$*	digital input	This signal is used with *$\overline{IREG.D}$* (pin 5) to set the regulation mode. See the description of pin 5 for the logic table associated with this signal.
7	**36**	*$\overline{ON.D}$*	digital input	If *OFF.D* (pin 14) is low, a momentary low on this pin will turn output power on.

Table 4-1. *User Port Pin Descriptions (Continued)*

Signal Pin	Return Pin	Pin Name	Signal Type	Description
8	**n/a**	unassigned	n/a	n/a
9	**n/a**	*OUTCOM.A*	n/a	Dedicated return for analog output. Reference pins 23, 24, 25, 31, and 32 to this pin.
10	**n/a**	*INCOM.A*	n/a	Dedicated return for analog input. Reference pin 27 to this pin.
11	**19**	$\overline{AUX.D}$	digital input	This signal, with $\overline{VAC.D}$ (pin 12) and $\overline{WATER.D}$ (pin 13) monitors the system interlock string. If the interlock conditions are not all satisfied, either the main contactor will not close or it will open (if it is already closed) when the interlock string is interrupted.
12	**19**	$\overline{VAC.D}$	digital input	See description of pin 11 ($\overline{AUX.D}$).
13	**19**	$\overline{WATER.D}$	digital input	See description of pin 11 ($\overline{AUX.D}$).
14	**36**	*OFF.D*	digital input	When this signal is high, it overrides all commands and forces a shut off of output power. It also resets the Pinnacle Plus+ unit after all fault conditions, except interlock, over-temperature, and A/D conversion faults. But it will not reset an “end of target life” signal.
15	**19**	*SPARE1.D*	digital input	spare input
16	**19**	*SPARE2.D*	digital input	spare input
17	**19**	*SPARE4.D*	digital input	spare input

Table 4-1. *User Port Pin Descriptions (Continued)*

Signal Pin	Return Pin	Pin Name	Signal Type	Description
18	**n/a**	*15 V*	output	This protected 15 V dc supply (output) provides a maximum of 100 mA.
19	**n/a**	*INTLKCOM.D*	n/a	Dedicated return for interlocks. Reference pins 11, 12, and 13 to this pin.
20	**37**	$\overline{CS2.D}$	digital output	This signal is used with pin 1 ($\overline{CS1.D}$) to tell an external device (such as a cathode switch box) which of the Pinnacle Plus+ supply's target-life counters is active. See description of pin 1 for the logic table.

Table 4-1. *User Port Pin Descriptions (Continued)*

Signal Pin	Return Pin	Pin Name	Signal Type	Description
21	**37**	$\overline{ARC.D}$	output	A pulse of a predetermined width (normally 100 ms—a few units are configured for 10 ms) will be seen on this pin under two different conditions: 1. If the hard arc count limit is non-zero and the number of hard arcs seen exceeded this limit during the last run, the pulse will occur when the output is turned off. 2. If you set the hard arc count limit to zero, this signal will pulse for a predetermined time for every hard arc seen by the unit. If another hard arc is seen before the last pulse is complete, the pulse width will be refreshed to the full width. These conditions will also be indicated through the ARC LED on a Passive Display Panel.

Table 4-1. *User Port Pin Descriptions (Continued)*

Signal Pin	Return Pin	Pin Name	Signal Type	Description
22	**37**	*EOTL.D* or *READY.D*	digital output	Normally, this pin is configured to signal the end of target life (*EOTL.D*), but if your unit was ordered (and configured) for use with an Advanced Energy Varian® interface unit, see *READY.D* below: • *EOTL.D*: This signal goes high when the active target-life counter reaches zero, thus indicating that target life has ended. • *READY.D* : If your unit is configured for use with an Advanced Energy Varian Interface unit, a digital low on this pin indicates faults are active (ready bit is de-asserted) and the unit is not ready to output power. A digital high on this pin indicates no faults are active and the unit is ready to output power—provided all other necessary conditions have been met.
23	**9**	*VOUT.A*	analog output	This signal represents output voltage. Full scale represents the rating of the supply (see the "Specifications" chapter of this manual for more information).

Table 4-1. *User Port Pin Descriptions (Continued)*

Signal Pin	Return Pin	Pin Name	Signal Type	Description
24	**9**	*POUT.A*	analog output	This signal represents output power. Full scale represents the rating of the supply (see the “Specifications” chapter of this manual for more information.)
25	**9**	*IOUT.A*	analog output	This signal represents output current. Full scale represents the rating of the supply (see the "Specifications" chapter of this manual for more information).
26	**n/a**	unassigned	n/a	n/a
27		*LEVELIN.A*		This signal is used to program the output level. Full scale represents the rating of the supply for the active regulation mode (see the “Specifications” chapter of this manual for more information).
28	**n/a**	unassigned	n/a	n/a
29	**19**	*SPARE3.D*	digital input	Spare input
30	**n/a**	unassigned	n/a	n/a
31	**9**	*LEVELOUT.A*	analog output	This signal represents the programmed set point level. Full scale represents the rating of the supply (see the “Specifications” chapter of this manual for more information).

Table 4-1. *User Port Pin Descriptions (Continued)*

Signal Pin	Return Pin	Pin Name	Signal Type	Description
32	**9**	*REF.A*	analog output	This signal provides an accurate 5 V or 10 V reference (10 V at 10 mV). The P2 jumper controls the level of this pin's reference signal. • To set the reference to 10 V, place the jumper across pins 1 and 2 • To reference to 5 V, place the jumper across pins 2 and 3
33	**n/a**	unassigned	n/a	n/a
34	**36**	$\overline{TARGET2.D}$	digital input	This signal is used with *TARGET0.D* (pin 4) and *TARGET1.D* (pin 35) to select the active target-life counter. See the description of pin 4 for the logic table associated with this signal.
35	**36**	$\overline{TARGET1.D}$	digital input	This signal is used with *TARGET0.D* (pin 4) and *TARGET2.D* (pin 34) to select the active target-life counter. See the description of pin 4 for the logic table associated with this signal.
36	**n/a**	*INCOM.D*	n/a	Dedicated return for digital inputs. Pins 4, 5, 6, 7, 14, 34, and 35 should be referenced to this pin.
37	**n/a**	*OUTCOM.D*	n/a	Dedicated return for digital outputs. Pins 1, 2, 3, 20, 21, and 22 should be referenced to this pin.

Table 4-2. *Cathode Switch (pin 20 and pin 1)*

Target-Life Counter	Pin 20	Pin 1
1 or 5	high	high
2 or 6	high	low
3 or 7	low	high
4 or 8	low	low

Table 4-3. *Target Life Counter (pin 34, 35, and 4)*

Target-Life Counter	Pin 34	Pin 35	Pin 4
1	low	low	low
2	low	low	high
3	low	high	low
4	low	high	high
5	high	low	low
6	high	low	high
7	high	high	low
8	high	high	high

Table 4-4. *Regulation Mode (pin 5 and pin 6)*

Regulation Mode	Pin 5	Pin 6
Voltage	high	high
Power	high	low
Current	low	high
Not valid	low	low

PASSIVE DISPLAY PANEL

The passive front panel and remote passive panel let you monitor power, current, or voltage; receive error codes; and review several other conditions shown by the LEDs.

Display

At any time while the Pinnacle Plus+ supply is operating, you can press the DISPLAY button to the left of the four-digit display to find the number of kilowatts, volts, or amps being delivered or to display the frequency setting or the reverse time setting. The LEDs to the right of the screen indicate which value is being displayed. When both kW and V are lit, frequency is displayed (in kHz). When both V and A are lit, the reverse time is displayed (in µs). Repeatedly pressing the DISPLAY button will cause the display to cycle in the following order: kW, V, A, freq (frequency in kHz), and t-rev (reverse time in µs).

When a fault or software error occurs, the error codes scroll across the display (for example, E004...E002...E004...E002). These codes scroll indefinitely until you correct the errors. For a detailed explanation of the error codes and other troubleshooting materials, see the "Troubleshooting" chapter.

LEDs

Table 4-5. *Display Panel LEDs*

POWER ON	Lights green when input power is on
OUTPUT	Lights green if output power is on
SETPOINT	Lights green if the Pinnacle Plus+ supply is operating within set point; accuracy is within 0.4% of full scale or 2% of set point, whichever is greater
INTERLOCK	Lights green if all interlock conditions have been met
BUS FAULT	Lights green when a bus fault occurs

Table 4-5. *Display Panel LEDs (Continued)*

OVERTEMP	Lights green if the Pinnacle Plus+ supply has exceeded the maximum operating temperature
ARC	After the output has been turned off, this LED lights green for a predetermined time if the hard arc count limit was reached during the previous run. You define this limit. The ARC LED will be activated under two different conditions: 1. If the hard arc count limit is non-zero and the number of hard arcs seen exceeded this limit during the last run, the pulse will occur when the output is turned off. 2. If the hard arc count limit is set to zero, this signal will pulse for a predetermined time for every hard arc seen by the unit. If another hard arc is seen before the last pulse is complete, the pulse width will be refreshed to the full width.

ACTIVE FRONT PANEL/ PINNACLE REMOTE PANEL

The Pinnacle Plus+ supply presents a broad array of features and settings that you can easily control through the Pinnacle Remote Active Panel. If you are using the Pinnacle Remote Active Panel, first ensure that it has been properly connected to the Pinnacle Plus+ supply; installation information appears in the following section.

Connecting to the Remote Active Panel

The 9-pin, male, subminiature-D connector labeled REMOTE ACTIVE PANEL on the rear of the Pinnacle Plus+ power supply lets you connect the supply to the Pinnacle Remote Active Panel.

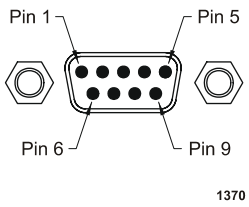

Figure 4-2. *Remote active panel connector*

The pin descriptions for this connector appear in the following table; installation instructions follow the pin description table.

Table 4-6. *Remote Panel Pin Descriptions*

Pin	Description
1	Do not connect
2	Do not connect
3	Do not connect
4	Do not connect
5	Ground
6	TR-
7	TR+
8	R-
9	R+

To connect your Pinnacle Plus+ power supply to the Pinnacle Remote Active Panel:

1. Connect the cable between the REMOTE ACTIVE PANEL connector on the Pinnacle Plus+ supply and the Pinnacle Remote Active Panel.

Understanding the Panel

CONTROL KEY

To control your Pinnacle Plus+ supply from the panel, select local mode by pressing the CONTROL key on the panel until the LOCAL LED lights. Placing the unit in local mode gives you full access to the front panel menu (see “Control Panel Interface” on page 4-16).

To control the Pinnacle Plus+ supply from the Serial interfaces or the DeviceNet port, press the CONTROL key until the HOST LED lights. To control the Pinnacle Plus+ supply from the User port, press the CONTROL key until the USER LED lights. When the Pinnacle Plus+ unit is in host or user control mode, you can view all the menu items, but you cannot modify parameters or lock the display.

OUTPUT DISPLAY SCREEN

The first screen that appears on the panel's vacuum fluorescent display when you power up is the “output display screen.” See “Two-Line Output Display Screen” on page 4-18 for more information.

Viewing Output Information

The output display screen shows the actual output level in volts, amps, and watts. (See the front panel drawings at the end of the “Installation” chapter.) It also displays the set point.

Selecting Set Point

To program the set point level from an active control panel, use the panel's CONTROL key to select local control mode (the LOCAL LED will light). (See “Setting Control Parameters” on page 4-39.) Activate the set point value, then turn the MODIFY knob until the set point you want is displayed, then deactivate the set point value.

See below for more information about the MODIFY knob.

SOFT KEYS

The five unlabeled soft keys directly below the vacuum fluorescent display let you select menu choices. Menu choices appear on the second line of the display. Since different selections (different menu levels) are displayed at different times, this manual refers to the soft keys by whichever terms are displayed above them. For example, you are instructed to press the ARC soft key when ARC is the menu choice directly above that particular key.

See Figure 4-3 on page 4-16 and Figure 4-5 on page 4-20.

MODIFY KNOB

Use the MODIFY knob to change values and move through the menus. When the display screen shows a flashing value, you can change it by turning the MODIFY knob. In addition, you can use the MODIFY knob to move quickly through the menus. Pressing the MODIFY knob once moves you up one level in the menu. Pressing it twice quickly moves you all the way out of the menu to the output display screen.

REGULATION KEY

At the SETPT menu, choose one of three methods of output regulation (power, current, or voltage) by pressing the REGULATION key until the desired LED lights.

Note: You cannot change regulation modes when output is on.

ON/OFF BUTTONS & LEDS

The ON and OFF keys on the remote panel turn on and off the output power. The relevant LED lights to indicate output is on or off.

ARC LED

After the output has been turned off, this LED lights green for a predetermined time if the hard arc count limit was reached during the previous run. You define this limit through a control panel or with Command **9**. You define the voltage trip level for arcs through a control panel or with Command **10**. You can enable arc handling through a control panel or with Command **61** of the Standard Serial port.

Note: If you set the hard arc count limit to zero, the ARC LED lights for a predetermined time and, if applicable, sends a signal to the User port for every hard arc seen by the unit.

See “Enabling Arc Handling” on page 4-39 for more information.

CONTROL PANEL INTERFACE

Your Pinnacle Plus+ unit may have either an active front panel, which is an integrated part of the unit, or an active remote panel, which is connected to the DISPLAY port on the rear panel of the unit. *This manual uses the term “control panel” to refer to either of these panels since they function identically*.

An active control panel has three main sections:

- ON and OFF switches at the far left of the panel
- CONTROL and REGULATION switches at the far right of the panel
- A two-line display, five soft keys, and a MODIFY knob

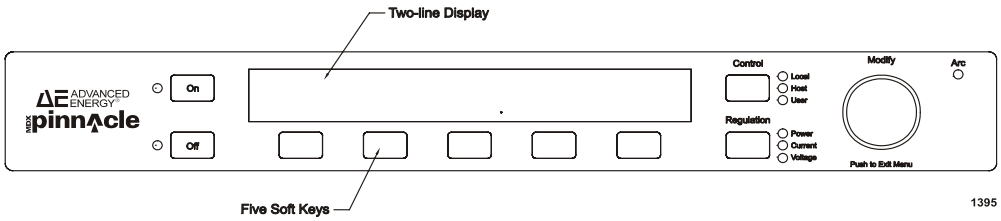

Figure 4-3. *Control panel*

Output Power Key

Use the following keys to turn output power on and off.

Table 4-7. Output Power Keys

ON	Turns on output power if the control panel has control of the on/off function and all interlock conditions are satisfied.
OFF	Turns off output power, no matter which interface is currently controlling the unit.

Control Key

To control your Pinnacle Plus+ supply from the panel, select local mode by pressing the CONTROL key on the panel until the LOCAL LED lights. Placing the unit in local mode gives you full access to the front panel menu.

To control the Pinnacle Plus+ supply from a serial interface or the DeviceNet port, press the CONTROL key until the HOST LED lights. To control the Pinnacle Plus+ supply from the User port, press the CONTROL key until the USER LED lights. When the Pinnacle Plus+ unit is in host or user control mode, you can view all the menu items, but you cannot modify parameters or lock the display.

Note: You can *not* change control modes while output power is energized (on).

Table 4-8. Control Key LEDs

LOCAL	Specifies that control of the Pinnacle Plus+ power supply has been assigned to the control panel.
HOST	Specifies that control of the Pinnacle Plus+ power supply has been assigned to a serial interface (that is, Host port, DeviceNet port, or standard serial port).
USER	Specifies that control of the Pinnacle Plus+ power supply has been assigned to the User port. *Note:* User control can only be selected when a User port interface card is installed in the unit.

Regulation Key

Use this key to select the method of output regulation when the control panel has control (local control).

Note: You can not change regulation modes while output power is energized (on).

Table 4-9. Regulation Key LEDs

POWER	Specifies that the method of output regulation is *power*.
CURRENT	Specifies that the method of output regulation is *current*.
VOLTAGE	Specifies that the method of output regulation is *voltage*.

Two-Line Output Display Screen

The display screen displays two lines of information. When you first power up, the display screen appears.

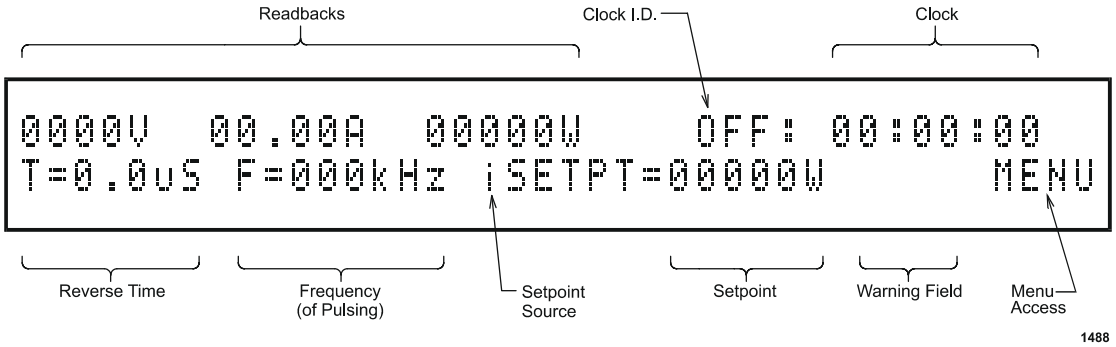

Figure 4-4. *Two-line output display screen*

The following information appears in the top line of the display (left to right):

- Voltage readback
- Current readback (in amps)
- Power readback (in watts)
- Clock ID: what the supply is doing
  - RMP = output is on and ramping
  - RUN = output is on and the clock shows the elapsed time
  - OFF = output is off and the clock shows the last run time
- Clock

  Note: If the last run time is < 1 minute, the seconds will display in hundredths precision. That is, 12 1/2 s will display as 12.50 s.

The following information appears in the bottom line of the display (left to right):

- Reverse time

- Frequency (of pulsing)
- Set Point Source (i = internal, e = external)
- Set Point
- Regulation mode (W = Power, A = Current, V = Volts)
- Warning field: flashes the following codes
  - ARCLIM = arc limit reached

    Note: ARCLIM is only active when the Hard Arc Counting feature is enabled.
  - EOTL = end of target life
  - OC = over-current condition
  - OV = over-voltage condition
- MENU soft key, which gives you direct access to the menu.

SETTING THE REVERSE TIME, FREQUENCY, AND SET POINT

To change the reverse time, frequency, or set point, press the soft key under the display. The units will flash, indicating that you can rotate the knob to change the value. Once you select a value, it's only active for editing (changing). You need to press the soft key again to enter the value. If you press another key before you press the soft key to enter the value, the new (edited) value will not be accepted. The one exception is the set point. The set point changes as you rotate the knob.

Soft Keys

Use the soft keys to select whichever menu functions are shown immediately above them on the two-line display. "Understanding the Menu Options" on page 4-20 explains how to perform these operations from the Pinnacle control panel.

Note: If you're at the top level, press the MENU soft key to make the menus appear.

Modify Knob

Use the MODIFY knob with the soft keys to change selections and modify values that appear on the two-line display.

CONTROL PANEL CONTROLS

Use the MODIFY knob and the five unlabeled soft keys that are directly below the display to select parameters and modify values. To changes parameters using the menu, the Pinnacle Plus+ unit must be in local control mode (the LOCAL LED will be illuminated).

Note: When the Pinnacle Plus+ unit is in User or serial (Host) mode, you can view all the menu items, but you cannot modify any of the items or lock the unit. If you switch the Pinnacle Plus+ unit to User mode while you are viewing an item in the menu, you are returned to the output display screen immediately.

Press the MENU soft key when the top level display screen is displayed to cause the main menu to appear. The main menu contains three menu selections, which are shown in the figure below. Generally, pressing a soft key causes another level of menu choices to display (for example, MONITOR, LIMITS, ARC, and CONTROL display if you press the PROCESS soft key).

Figure 4-5. *Control panel main menu functions*

As you press soft keys and move through the menu levels, the top line of the output display screen displays the path of the menu in the upper, left-hand corner of the display screen.

A parameter flashes if it can be modified; make such modifications with the MODIFY knob. Pressing the ENTER soft key enters the modification into nonvolatile memory. You can press the MODIFY knob at any time to cancel what you are doing (leave the parameter(s) unchanged) and return to the output display screen.

If a fault exists or the panel is locked, the soft keys are locked out until you clear the fault. See “Troubleshooting and Global Customer Support” on page -1 for a list of fault messages.

UNDERSTANDING THE MENU OPTIONS

Pressing the rightmost soft key will bring up the main menu tree. When at the top level, you have three menu options:

- Service
- Supply

- Process

From the Service menu, you can access diagnostic information. From the Supply menu, you can modify supply-specific parameters, and from the Process menu, you can access options that affect your process or monitor your process. To select a menu option, press the soft key below the menu option. See the menu maps for a graphical representation of the menu options.

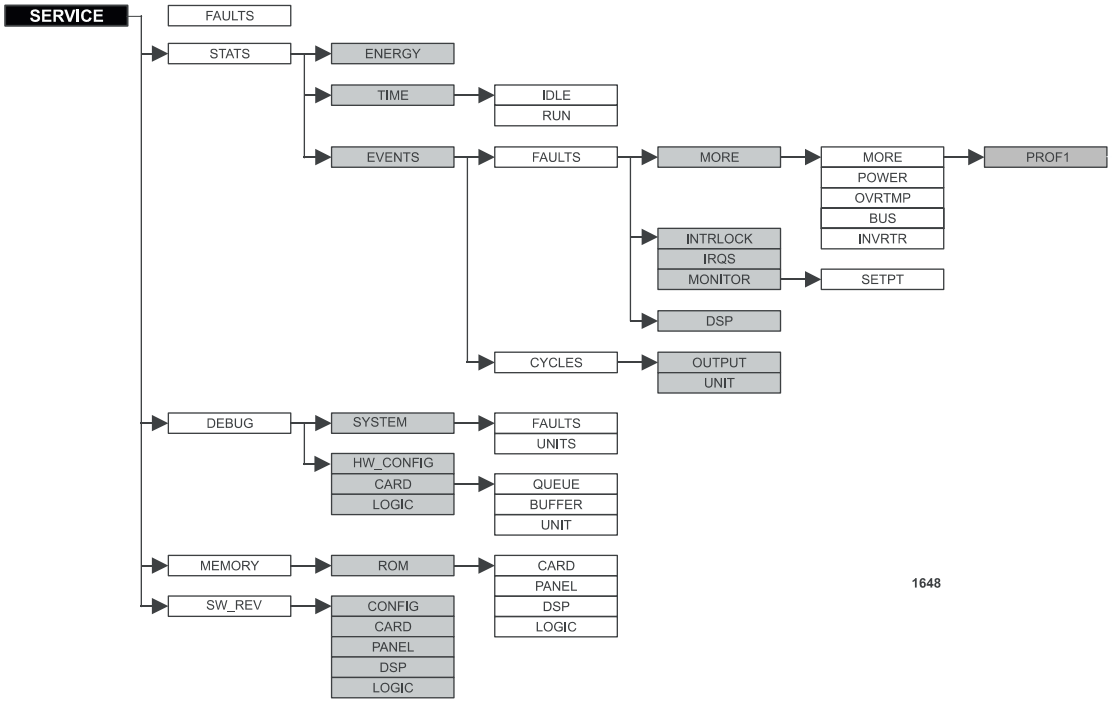

Figure 4-6. *Service menu map*

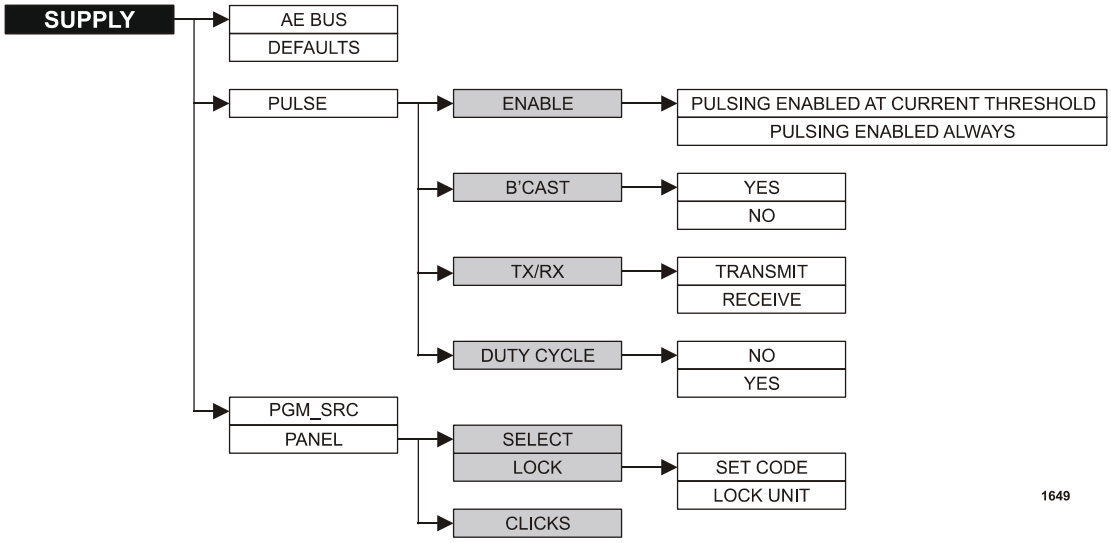

Figure 4-7. *Supply menu map*

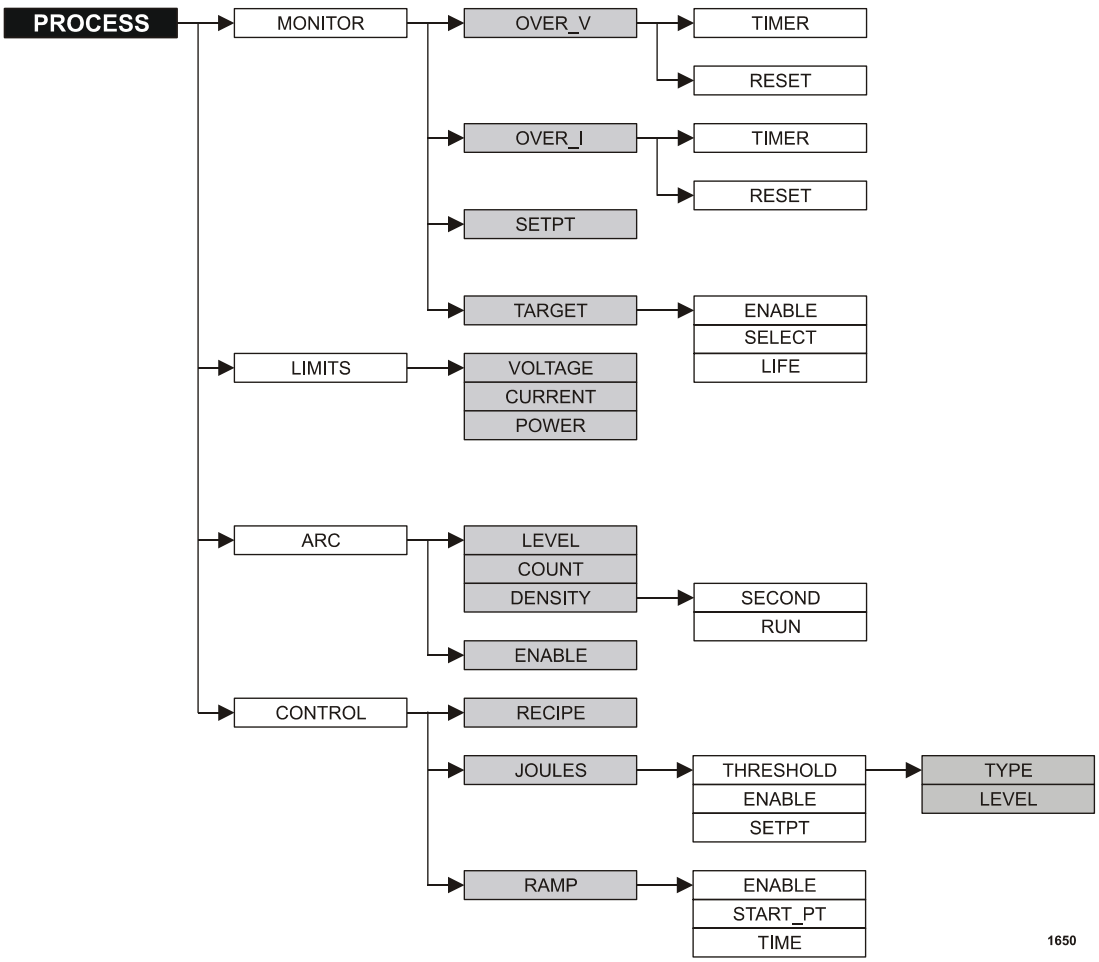

Figure 4-8. *Process menu map*

USING THE SERVICE FUNCTIONS

Use this option to view diagnostics and software versions of your supply. The menu options are:

- FAULTS: customer service information
- STATS: supply statistics
- DEBUG: debug screens
- MEMORY: ROM CRC checksums
- SW_REV: software revision numbers

Checking Service-type Faults

SERVICE → FAULTS

Customer service will use this option.

Checking Service-type Statistics

SERVICE → STATS

Use this option to check the service-type statistics.

CHECKING THE TOTAL ENERGY OUTPUT

SERVICE → STATS → ENERGY

To check the total energy output:

- Press SERVICE → STATS → ENERGY.
  - The total energy output for the unit appears.

CHECKING THE AMOUNT OF IDLE TIME

SERVICE → STATS → TIME

To check the amount of time idle and the amount of time running:

1. Press SERVICE → STATS → TIME.
2. To display the amount of time idle, press the IDLE soft key.
   - The amount of time idle appears.
3. To display the amount of time running, press the RUN soft key.
   - The amount of time running appears.

CHECKING THE NUMBER OF FAULTS

SERVICE → STATS → EVENTS

To check the number of faults:

1. Press SERVICE → STATS → EVENTS.

- FAULTS and CYCLES options appear.

2. Press the FAULTS soft key.
3. MORE, INTRLOCK, IRQS, MONITOR, and DSP options appear.
4. If you press MORE, you can check the following faults:
   - POWER displays the number of line power faults.
   - OVRTMP displays the number of over temperature faults.
   - BUS displays the number of bus faults.
   - INVRTR displays the number of inverter faults.
5. If you press INTRLOCK, the number of contactor, user, and cable faults appears.
6. If you press IRQ, the number of predefined and unassigned IRQs appears.
7. If you press MONITOR, you can check the number of set point timer faults and process voltage faults.
8. If you press DSP, the number of DSP control and DSP watch dog faults appears.

CHECKING THE NUMBER OF CYCLES

To check the cycles:

1. Press SERVICE → STATS → EVENTS.
   - FAULTS and CYCLES options appear.
2. Press the CYCLES soft key.
   - OUTPUT and UNIT options appear.
3. To get a report of the number of output on events, press the OUTPUT soft key.
4. To get a report of the number of power on events, press UNIT.

Debugging Your Unit

SERVICE → DEBUG

Use this option to check the hardware configuration, installed cards, and logic software options

CHECKING YOUR MASTER/SLAVE SYSTEM FAULTS

SERVICE → DEBUG → SYSTEM

Use this option to check for faults in your master/slave system. Select FAULTS to determine fault type; select UNITS to determine which units have faults.

Note: Master/Slave options are only available if your unit has a master/slave Host card installed.

CHECKING YOUR HARDWARE CONFIGURATION

SERVICE → DEBUG → HW CONFIG

To find out whether or not a card is installed in slot 1 or 2:

1. Press SERVICE → DEBUG → HW CONFIG.
   - A report of the personality cards installed in the supply in slot 1 and slot 2 appears.

CHECKING YOUR COMMUNICATIONS CARD

SERVICE → DEBUG → CARD

Use this option to find out specific communications debug information:

1. Press SERVICE → DEBUG → CARD.

   Note: Not all cards support this feature.

CHECKING YOUR SOFTWARE LOGIC

SERVICE → DEBUG → LOGIC

Use this option to find out what software logic options are installed.

1. Press SERVICE → DEBUG → LOGIC.
   - The configuration options display one at a time. Arrows above the first two soft keys allow you to move forward or backward. Selections that can be changed will appear with CHANGE on the 4th soft key. ENTER is on the 5th soft key in all cases.
2. Use the arrow keys to move to the selection you want.
3. Press the 4th soft key (CHANGE) to select the change, and then press the 5th soft key (ENTER). The change is accepted and you are returned to the Service_Debug level.

   Note: Pressing the knob also returns you to the Service_Debug level, but the change is not saved.

The following are the available configuration options. Note that certain configuration options are reset immediately, while others require cycling power on the unit.

RAMP RESOLUTION: 10ms to 100ms; changes immediately.

JOULE RECIPE STATUS: Redefine the Profibus upload status bits; changes immediately.

USER-PORT EOTL DEFINED AS: Changes the definition form indicating End of Target Life (EOTL) or a ready signal; changes immediately.

HIGH SPEED AEBUS: Changes the baud rates; requires a power cycle on the unit before the change takes effect. The following are the baud rates when HIGH SPEED AEBUS is disabled or enabled:

Table 4-10. Baud Rates When HIGH SPEED AEBUS is Disabled/Enabled

Disabled	Enabled (Same for RS232/422/485)
1200	19200
4800	38400
9600	57600
19200	115200

EXPLICIT FAULT CLEARING: Changes the fault clearing method; changes immediately. When method is set to DISABLED, power must be cycled on the unit to clear the fault. When method is set to ENABLED, the OFF or RESET command will clear the fault.

Checking Your ROM

SERVICE → MEMORY

To perform ROM cyclic redundancy check (CRC) checking:

Note: There is a momentary delay before the CRC will display.

Note: Not all cards support this option.

1. Press SERVICE → MEMORY → ROM → CARD.
2. To calculate and display the active panel (local or remote) CRC, press PANEL.
3. To calculate and display the DSP CRC, press DSP.
4. To calculate and display the logic board CRC, press LOGIC.

Checking Your Software Versions

SERVICE → SW_REV

To find out the software number and version of your system software components:

1. Press SERVICE → SW_REV.
2. To display the software version of the configuration, press CONFIG.
3. To display the software version of the cards installed in your unit, press CARD.
4. To display the software version of the active panel software, press PANEL.

5. To display the software version of the DSP software, press DSP.
6. To display the software version of the logic, press LOGIC.

USING THE SUPPLY FUNCTIONS

This option lets you modify specific components and parameters of your supply. The menu options are:

- AEBUS:
- DEFAULTS:
- PULSE:
- PANEL:
- PGM_SRC:

Setting the AE Bus Timeout

SUPPLY → AE BUS

To set your AE Bus timeout time:

1. Press SUPPLY → AEBUS.
2. Rotate the MODIFY knob to adjust the AE Bus time out value (in 10 ms increments).
3. Press ENTER to accept and exit.

Note: We recommend you use the default value of 200 ms.

Setting the Supply Parameters

SUPPLY → DEFAULTS

To set all your supply parameters to the defaults and then store them in non-volatile memory:

1. Press SUPPLY → DEFAULTS.
2. Rotate the MODIFY knob to display YES or NO.
3. Press ENTER to accept and exit.

Setting Pulse Parameters

SUPPLY → PULSE

Use this menu entry to alter pulsing-type parameters.

ENABLING PULSING AT CURRENT THRESHOLD OR ALWAYS

SUPPLY → PULSE → ENABLE

Use this menu function to enable pulsing at the current threshold (default setting), or to enable pulsing always. If the unit is set to pulse at the current threshold, pulsing is disabled until the Pinnacle Plus+ unit detects current flow above the current threshold. At this point the unit will begin to pulse. For more information, see “High Power Operation” on page 6-5.

If the unit is set to pulse always, the unit will pulse from the moment it is energized. For more information, see “Low Power Operation” on page 6-4.

Note: If you choose to pulse always and set a high power operation power limit, the upper-end pulsing frequency limit is 150 kHz. See “High Power Operation” on page 6-5 for information about high power operation.

To enable pulsing at the current threshold or always:

1. Press SUPPLY → PULSE → ENABLE.
2. Rotate the MODIFY knob to display PULSING ENABLED AT CURRENT THRESHOLD or PULSING ENABLED ALWAYS.
3. Press ENTER to accept and exit.

SETTING SYNC PULSE HARD ARC DETECTION BROADCAST

SUPPLY → PULSE → B’CAST

Note: This feature is *only* available if your Pinnacle Plus+ unit was specifically configured at the factory for Sync Pulse.

If Sync Pulse hard arc detection broadcast (B’CAST) is enabled, all units handle hard arcs in synchronization with each other no matter which unit detects the hard arc, or where the hard arc occurs.

To set Sync Pulse hard arc detection broadcast:

1. Press SUPPLY → PULSE → B’CAST
2. Select YES or NO to enable or disable this function.

If your unit is configured with a Sync Pulse port you may set up to six Pinnacle Plus+ units in a Sync Pulse system. See the section titled “Master/Slave Operation” near the end of chapter 5 of this manual for more information.

SETTING THE UNIT AS A SYNC PULSE TRANSMITTER OR RECEIVER

SUPPLY → PULSE → TX/RX

Note: This feature is *only* available if your Pinnacle Plus+ unit was specifically configured at the factory for Sync Pulse.

To set the unit as a Sync Pulse transmitter or receiver:

- Press SUPPLY → PULSE → TX/RX.
- Select TRANSMIT or RECEIVE.

Note: **One unit must be set to transmit; all other units *must* be set to receive.**

If your unit is configured with a Sync Pulse port you may set up to six Pinnacle Plus+ units to operate in a Sync Pulse system. See the section titled "Master/Slave Operation" near the end of chapter 5 of this manual for more information.

Selecting Constant Duty Cycle

SUPPLY → PULSE → DUTY_CYC

The constant duty cycle feature automatically updates the reverse time when you change frequency, allowing you to maintain the same duty cycle that was present before the change—within a limited frequency range.

Note: To change the duty cycle, change the reverse time.

To select the constant duty cycle feature:

1. Press SUPPLY → PULSE → DUTY_CYC.
2. Select YES to enable function.

Setting the Program Source

SUPPLY → PGM_SRC

The program source (PGM_SRC) feature specifies for each control mode the program source for regulation mode and set point information. For each control mode, if the program source is set to internal (INT), the Pinnacle Plus+ supply uses the information for output regulation mode and set point that has been established through the active front panel, the Pinnacle Remote Active Panel, or the standard serial port. If the program source is set to external (EXT), the Pinnacle Plus+ supply uses the set point and output regulation mode that has been established through the pins on the User port.

To select the desired source and type:

1. Press SUPPLY → PGM_SRC.

HOST, LOCAL, and USER options appear. Press one of these buttons to toggle between internal and external for that types.

2. Press EXIT.

Note: A user card must be installed in order to alter these settings.

Setting the Panel Mode

SUPPLY → PANEL

Use this option to select between a remote and local control panel, lock the control panel, set the lock code, or set the encoder rate for the knob clicks.

SELECTING REMOTE OR LOCAL MODE

SUPPLY → PANEL→ SELECT

To switch between the remote active panel and the local active panel:

1. Press SUPPLY → PANEL → SELECT.
2. Rotate the MODIFY knob to display YES or NO, depending on whether or not you want to switch to a remote/local active panel.
3. Press ENTER to accept and exit.
4. Wait several seconds for verification of switch before using the other control panel.

SELECTING A LOCK CODE

SUPPLY → PANEL→ LOCK

To enter a lock code for locking the active control panel:

1. Press SUPPLY → PANEL → LOCK.
   - SET CODE and LOCK UNIT options appear.
2. To set a lock code, press the SET CODE soft key. If a code is already entered, press LOCK UNIT.
   - Any further menu accesses will require entry of the code.

   Note: Cycling power on the supply resets the lock status to UNLOCKED.

SELECTING THE NUMBER OF CLICKS

SUPPLY → PANEL→ CLICKS

The clicks feature specifies the number of high speed counts per click for the MODIFY knob. The value you enter is a multiplier for each click of the knob when you turn the knob quickly. When you turn the knob slowly, the multiplier does not take effect. Valid entries are 1 to 40. If you want a displayed value to change slowly as you turn the knob, set the number of counts per click to 1. If you want the value to change quickly, set the number of counts to 40.

To change the number of counts per click:

1. Press SUPPLY → PANEL → CLICKS.
2. Rotate the MODIFY knob to set the number of counts per click.
3. Press ENTER to accept and exit.

USING PROCESS FUNCTIONS

Use this option to access parameters that control, limit, or monitor your process. The menu options are:

- MONITOR: monitor your process
- LIMITS: set limits
- ARC: set arc parameters
- CONTROL: set process control parameters

Monitoring Your Process

PROCESS → MONITOR

This menu allows you to monitor elements of your process such as the life of your target, how long the process is running out of set point, or whether the process voltage drops below its threshold.

Note: In all cases, the voltage and current are measured at the DC inverter output. (See Figure 2-1 on page 2-2.)

VIEWING THE OVER-VOLTAGE DENSITY

PROCESS → MONITOR → OVER_V

Use this menu to view the density of unit over-voltage responses per run (a response is an action taken by the Pinnacle Plus+ supply to minimize over-voltage conditions). When the unit detects an over-voltage condition, it triggers an algorithm that controls the user voltage limit in order to minimize and eliminate over-voltage events.

To view the over-voltage density:

1. Press PROCESS → MONITOR → OVER_V

   Note: When you see the counter increment or "OV" flashing in the top level menu of the output display screen, the algorithm is active or has just run. For an illustration of the output display screen, see "Two-Line Output Display Screen" on page 4-18.

RESETTING THE OVER-VOLTAGE DENSITY

PROCESS → MONITOR → OVER_V → RESET

Use this option to reset the over-voltage density counter to zero. You can use this feature to characterize a process by recording the over-voltage counter over the same time period for every parameter change in the process. To use the over-voltage counter in this way, reset both the counter and the period timing at the start of a parameter change. Record the counter at the end of the timed period and repeat.

To reset the over-voltage density counter:

1. Press PROCESS → MONITOR → OVER_V → RESET.

SETTING THE OVER-VOLTAGE TIMER

PROCESS → MONITOR → OVER_V → TIMER

Use this option to enable and set the over-voltage timer. This function lets you indicate how long you want the power supply to tolerate an over-voltage condition before it shuts off output.

When the timer expires, the unit shuts off output and displays error code E086 (see "Error Code Troubleshooting Table" on page 7-13) or passive front panel help code H026 (see "Help Code Troubleshooting Table" on page 7-6).

To enable the over-voltage timer, follow these steps to select a value (in 0.1 s increments). To disable the timer, follow these steps and select a value of 0.

1. Press PROCESS → MONITOR→ OVER_V → TIMER.
2. Rotate the MODIFY knob to adjust the value.
3. Press ENTER to accept and exit.

VIEWING THE OVER-CURRENT DENSITY

PROCESS → MONITOR → OVER_I

Use this menu to view the density of unit over-current responses per run.

To view the over-current density:

1. Press PROCESS → MONITOR → OVER_I.

   Note: When you see the counter increment or "OC" flashing in the top level menu of the output display screen, an over-current condition is active. For an illustration of the output display screen, see "Two-Line Output Display Screen" on page 4-18.

RESETTING THE OVER-CURRENT DENSITY

PROCESS → MONITOR → OVER_I → RESET

Use this option to reset the over-current density counter to zero. You can use this feature to characterize a process by recording the over-current counter over the same time period for every parameter change in the process. To use the over-current counter in this way, reset both the counter and the period timing at the start of a parameter change. Record the counter at the end of the timed period and repeat.

To reset the over-current density counter:

1. Press PROCESS → MONITOR → OVER_I → RESET.

SETTING THE OVER-CURRENT TIMER

PROCESS → MONITOR→ OVER_I → TIMER

Use this option to enable and set an over-current timer. This function lets you indicate how long you want the power supply to tolerate an over-current condition before it shuts off output.

When the timer expires, the unit shuts off output and displays error code E087 (see "Error Code Troubleshooting Table" on page 7-13) or passive front panel help code H027 (see "Error Code Troubleshooting Table" on page 7-13).

To enable the over-current timer, follow these steps to select a value (in 0.1 s increments). To disable the timer, follow these steps and select a value of 0.

1. Press PROCESS → MONITOR → OVER_I → TIMER.
2. Rotate the MODIFY knob to adjust the value.
3. Press ENTER to accept and exit.

SETTING THE OUT-OF-SET POINT TIMER

PROCESS → MONITOR→ SETPT

Use this option to enable and set an out-of-set point timer. This function lets you indicate how long you want the power supply to tolerate an out-of-set point condition before it shuts off output. An out-of-set point condition occurs whenever output moves out of a range determined by your selected set point (see page 4-39).

Out-of-Set Point Tolerance Range = Set point ±0.4% of full scale or 2% of set point, whichever is greater.

When an out-of-set point condition occurs, the unit shuts off output and displays error code E001. (See the "Error Codes" section of the "Troubleshooting" chapter for more information about error codes).

To enable the out-of-set point timer, follow these steps to select a value (in 0.1 s increments). To disable the timer, follow these steps and select a value of 0.

Note: Because the readbacks, which are compared to the set point, are filtered in the software, we recommend you do not use this feature for process runs that are less than 1 s.

1. Press PROCESS → MONITOR→ SETPT.
2. Rotate the MODIFY knob to adjust the value.
3. Press ENTER to accept and exit.

CHANGING THE TARGET FUNCTIONS

PROCESS → MONITOR→ TARGET

The target functions let you enable or disable the target life counter (ENABLE), change the active target (SELECT), and set the target life (LIFE) in 0.01 KWh increments.

PROCESS → MONITOR→ TARGET → ENABLE

To enable or disable the target life counter for the selected target:

1. Press PROCESS → MONITOR → TARGET → ENABLE.
2. Rotate the Modify knob to select YES or NO.
3. Press ENTER to accept and exit.

PROCESS → MONITOR→ TARGET → SELECT

To change the active target life counter:

1. Press PROCESS → MONITOR → TARGET → SELECT.
2. Rotate the MODIFY knob to select the active target number.
3. Press ENTER to accept and exit.

Note: The User port has priority in selecting targets. Thus, if your unit has a user card installed, you must set the target to 1 at the User port if you want to select targets from the serial port, active front panel, or Pinnacle Remote Active Panel (that is, when the Pinnacle Plus+ unit is in host or local control mode). Leaving the target bits open or leaving the User port pins unconnected causes the target selection at the User port to default to 1. When the User port is set to a target other than 1, the User port selection

has priority. If a change to the target is attempted on the front panel, “User Port Has PRIORITY” displays, and you must depress the MODIFY knob to exit (ENTER is no longer displayed).

PROCESS → MONITOR→ TARGET → LIFE

To set the target life in 0.01 kWh increments:

1. Press PROCESS → MONITOR → TARGET → LIFE.
2. Rotate the MODIFY knob to select a target life between 0 and 15000.00 kWh (The default is 0).
   - If you are rotating the MODIFY knob slowly, press the appropriate soft key to indicate how quickly you want the display to increment the value (x1000, x100, x10 or x1). Note: If you turn the MODIFY knob quickly, the counts per click setting takes effect.
3. Press ENTER to accept and exit.

This function will also display how much target life is left as the counter decreases.

When the end-of-target-life is reached, the output display screen flashes “EOTL” and the Pinnacle Plus+ unit continues running until a normal off command is received.

Note: **The Pinnacle Plus+ unit cannot turn back on until the target life is reset or until the target status is disabled or a new active target is selected.**

Setting Process Limits

PROCESS → LIMITS

This menu lets you control user-selectable operating limits for the Pinnacle Plus+ unit: maximum output (voltage, current, and power).

Note: Before entering a maximum output limit, consider your system's output impedance and consider how your selected power limits will interact. The unit will limit output when output reaches the first applicable limit.

Note: You cannot set a set point greater than the corresponding limit in that regulation mode.

SETTING A MAXIMUM LIMIT FOR OUTPUT VOLTAGE

PROCESS → LIMITS → VOLTAGE

This function lets you set a maximum limit for output voltage as measured at the DC inverter output (see Figure 2-1 on page 2-2). The maximum allowable value is the maximum rated output for the supply.

To set the user voltage limit:

1. Press PROCESS → LIMITS → VOLTAGE.

2. Rotate the MODIFY knob to select a value between 0 and the maximum rated output voltage for the supply.
3. Press ENTER to accept and exit.

SETTING THE MAXIMUM LIMIT FOR OUTPUT CURRENT

PROCESS → LIMITS → CURRENT

This function lets you set a maximum limit for output current. The maximum allowable value is the maximum rated output for the supply.

To set the user current limit:

1. Press PROCESS → LIMITS → CURRENT.
2. Rotate the MODIFY knob to select a value between 0 and the maximum rated output current for the supply.
3. Press ENTER to accept and exit.

SETTING THE MAXIMUM LIMIT FOR OUTPUT POWER

PROCESS → LIMITS → POWER

This function lets you set a maximum limit for output power. The maximum allowable value is the maximum rated output for the supply.

To set the user power limit:

1. Press PROCESS → LIMITS → POWER.
2. Rotate the MODIFY knob to select a value between 0 and the maximum rated output power.
3. Press ENTER to accept and exit.

Setting Arc Handling

PROCESS → ARC

Use the ARC menu to implement arc-handling during your normal process cycle or during standby. Selections in the ARC menu let you establish arc-handling parameters for normal process runs. In addition, the PROCESS menu lets you view arc density statistics.

SETTING THE VOLTAGE ARC TRIP LEVEL

PROCESS → ARC → LEVEL

This function lets you set the voltage arc trip level, that is, the output voltage level as measured at the DC inverter output (see Figure 2-1 on page 2-2), at which the unit determines an arc is occurring. If the voltage level is changing below the specified trip level, the Pinnacle Plus+ supply reacts by shutting down the output for 5 µs in the case of a micro arc, and 200 µs in case of a hard arc.

To set the arc trip level:

1. Press PROCESS → ARC → LEVEL.
2. Rotate the MODIFY knob to select an arc trip level.
3. Press ENTER to accept and exit.

SETTING THE ARC COUNT LIMIT

PROCESS → ARC → COUNT

This function lets you set a maximum limit of hard arcs that can occur during a run. If the limit is exceeded, the "ARCLIM" message appears in the warning field of the display, and the ARC LED lights and the "*ARC.D*" digital output line on the user card is toggled low for a predetermined time when output power is shut off (if applicable).

To set the hard arc count limit:

1. Press PROCESS → ARC → COUNT.
2. Rotate the MODIFY knob to select a hard arc count limit.

   Note: To enable the arc count limit feature, you must enter a value greater than 0. If you set the limit to 0, the ARC LED lights (for a predetermined time) each time a hard arc is seen by the unit.

3. Press ENTER to accept and exit.

VIEWING THE ARC DENSITY

PROCESS → ARC → DENSITY

The arc counter counts one arc every time the output is shut off due to a hard arc condition. The micro arc counter counts one arc every time a micro arc occurs. Both counters will reset the next time the Pinnacle Plus+ unit is powered on.

To see the arc density of your process:

1. Press PROCESS → ARC → DENSITY.

   ▸ SECOND and RUN options appear.

2. To see arcs per second, press SECOND.
3. To see arcs per run, press RUN.

   Note: This display is not zeroed until you turn the output on again, or reset the display.

4. Press EXIT to exit.

Note: You may press RESET at any time at this menu level to clear the arc counters.

SETTING THE ARC SHUTDOWN TIME

PROCESS → ARC → TIME

To set the arc shutdown time:

1. Press PROCESS → ARC → TIME.
2. Press the soft key under A/B to select side A or B. An arrow displays next to the letter of the side that is currently selected.
3. Rotate the MODIFY knob to select the arc shutdown value (in microseconds).
4. Press ENTER to save your selection and exit.

ENABLING ARC HANDLING

PROCESS → ARC → ENABLE

This function enables or disables the arc handling functions of the Pinnacle Plus+ supply.

CAUTION:
Default at power up is micro and hard arc handling enabled. If you choose to disable micro arc handling, your Pinnacle Plus+ unit will not respond to micro arcs, which could potentially affect your process. You cannot disable hard arc handling.

To disable the arc handling:

1. Press PROCESS → ARC → ENABLE.
2. Select Yes or No for MICRO arc handling.
3. Press ENTER to accept and exit.

Note: As an inherent safety feature, cycling power to the unit resets arc handling to enabled.

Note: Hard arc handling is always enabled.

Setting Control Parameters

PROCESS → CONTROL

Use this menu option to set up Pinnacle parameters that directly control the output of your process.

The menu options are:

- RECIPE
- JOULES
- RAMP

Setting Recipes

PROCESS → CONTROL → RECIPE

Note: If you are using recipes, you cannot use the standard joule mode. You can set up both recipes and joules, however, when running recipes the joule feature isn't triggered. You must use the joule recipe feature to have this functionality.

Use the RECIPE menu to implement a ramping recipe. This function lets you program the Pinnacle Plus+ to ramp up in incremental steps (1 to 8 steps are possible). For each step, you must set a ramp time, a set point, and a run timer. Ramp time is the amount of time (in seconds) that the Pinnacle Plus+ takes to ramp up to the set point for the specified step. Run timer is the amount of time (in seconds) for which the Pinnacle Plus+ unit runs at set point for the specified step.

Note: To enable this function, set the number of steps to 1, 2, 3, 4, 5, 6, 7, or 8. To disable this function, set the number of steps to 0.

To set the number of recipe steps:

1. Choose the regulation mode.

   Note: Use the REGULATION key to toggle between power, current and voltage. Use the MODIFY knob to select a value between 0 and the full rated output of the supply.

2. Press PROCESS → CONTROL → RECIPE.
3. Rotate the MODIFY knob to select a value from 1 through 8.
4. Press ENTER; the display progresses to a series of screens through which you enter ramp time, set point, and run timer for each step.

To set the ramp time, set point, and run timer value for each step:

1. After you have entered a value from 1 through 8 at the # OF STEPS screen (see steps 1 and 2 above), you should be looking at a screen that requests a RAMP TIMER value.
2. Rotate the MODIFY knob to select a value from 0 to 600 s (in 0.01 s increments).
3. Press ENTER; the display progresses to a screen requesting a SETPOINT value.
4. Press ENTER; the display progresses to a screen requesting a RUN TIMER value.

5. Rotate the MODIFY knob to select a value between 0.00 s to 600 s (in 0.01 s increments).

   Note: If you turn the MODIFY knob quickly, the counts per click setting takes effect.

6. Press ENTER; if you have indicated that your recipe contains more than one step, the display returns to the RAMP TIMER screen so that you can enter recipe values for the next step.
7. Repeat Steps 2 through 7 as needed.

   Note: If you assign 0 run time for the final recipe step, the unit will switch to continuous output when it reaches set point for this step. In this situation, to turn off output, you must send an off command (using the OFF button or the appropriate User port signal or serial port command) or you must have already programmed a joules set point.

To set the recipe type:

1. From the RECIPE menu options, press TYPE.
2. A screen displays that allows you to set the type as: TIMED, JOULE CONTINOUS, or JOULE DISCRETE.

   Use the Modify knob to make your selection. Press ENTER to save your selection.

3. If you set the recipe type to be JOULE CONTINOUS, a REPEAT menu option displays. Select REPEAT to enter the number of recipe repetitions. Use the Modify knob to enter an amount between 1 and 65535.

   Note: The recipe repetitions feature is only available with the JOULE CONTINUOUS option.

4. Press ENTER to save your selection.

Setting Joule Mode

PROCESS → CONTROL → JOULES

This option lets you use joule mode, a method of automatically delivering a specified number of joules to the target. Choose THRESHOLD to specify an output level to begin calculation and thereby enhance the accuracy of the calculation by disabling the calculation during ignition. Choose ENABLE to enable or disable joule mode. Choose SETPT to program the number of joules you want to be delivered.

Note: If a timed recipe is active, the timed recipe overrides the joule feature.

To enable joule mode:

1. Press PROCESS → CONTROL → JOULES → ENABLE.

2. Rotate the MODIFY knob to select YES or NO, to enable or disable joule mode.
3. Press ENTER to accept and exit.

SETTING THE JOULE SET POINT

To program the number of joules you want to be delivered (joule set point):

1. Press PROCESS → CONTROL → JOULES → SETPT.
2. Rotate the MODIFY knob to select a value between 0 and 9,999,999 joules (in 1 joule increments).
   - If you are rotating the MODIFY knob slowly, press the appropriate soft key to indicate how quickly you want the display to increment the value (x1000, x100, x10 or x1).

   Note: If you turn the MODIFY knob quickly, the counts per click setting takes effect.
3. Press ENTER to accept and exit.

SETTING THE JOULE THRESHOLD

PROCESS → CONTROL → JOULES→ THRESHOLD

This option allows you to set a level of output that must be met or exceeded before Joule calculation begins. You can use this feature to improve the accuracy for processes that have long ignition times.

To set the joule threshold type:

1. Press PROCESS → CONTROL → JOULES → THRESHOLD → TYPE
2. Rotate the MODIFY knob to select POWER, CURRENT, or VOLTAGE.
3. Press ENTER to accept and exit.

   Note: If you select power or current, the joule counter counts when power or current (which ever you selected) is above the threshold and stops when this value drops below the threshold. If you select voltage, the joule counter counts while voltage is below the threshold and stops when voltage exceeds this limit. The Joule energy calculation begins after (n) mS, regardless of the output level. The time value, (n) mS, is set in the configuration and cannot be changed. If the output level meets the joule energy threshold prior to the time expiration, the joule energy calculation will begin.

To set the joule threshold level:

1. Press PROCESS → CONTROL → JOULES → THRESHOLD → LEVEL

2. If you have selected power as your joule counter threshold type, then rotate the MODIFY knob to select a value between 10 W and maximum unit power divided by 8.

   Note: Value is in decawatts if unit is part of a master/slave system.

3. If you have selected current as your joule counter threshold type, then rotate the MODIFY knob to select a value between 0 and the maximum current set point for your unit.
4. If you have selected voltage as your joule counter threshold type, then rotate the MODIFY knob to select a value between 0 and 650 V.
5. Press ENTER to accept and exit.

Setting the Ramp

Use this option to ramp the output to a process set point. This option allows you to enable the feature, set a ramp start set point percentage, and set a ramp time. The ramp time is set in 10 ms increments. The minimum ramp time is 0.05 s. The maximum ramp time is 600.00 s.

Note: If your unit has 100 ms ramp feature enabled, the range is 0.5 s to 6000.0 s.

The out-of-set point timer is disabled while output is ramping.

PROCESS → CONTROL → RAMP

To enable ramp mode:

1. Press PROCESS → CONTROL → RAMP → ENABLE.
2. Rotate the MODIFY knob to select Yes or No to enable or disable ramp mode.
3. Press ENTER to accept and exit.

To select the ramp starting point (a percentage of the set point to begin ramping):

1. Press PROCESS → CONTROL → RAMP → START_PT.
2. Rotate the MODIFY knob to select a percent.
3. Press ENTER to accept and exit.

To select the ramp time:

1. Press PROCESS → CONTROL → RAMP → TIME.
2. Rotate the MODIFY knob to select a time.
3. Press ENTER to accept and exit.

   Note: Under “Host” control one can generate multiple ramps between set points by sending new set points while the output is on.

STANDARD SERIAL (FLASH) PORT

Your Pinnacle Plus+ supply contains a modified AE Bus serial (Host) communications interface accessible through the Standard Serial port. This allows the Pinnacle Plus+ unit to interface with a host computer. You can do everything from the host computer interfaced with the Pinnacle Plus+ supply that you can do from the active front panel or the Pinnacle Remote Panel. For a complete list of available functions, refer to the list of commands later in this chapter.

Note: To obtain a diskette containing sample software as well as an executable version of the AE Bus Host software, please call AE Customer Support.

Note: The flash port is *not* available for serial communications on Pinnacle Plus+ supplies with AE Bus cards installed.

Standard Serial Port Description

The Standard Serial port, or flash port, lets AE personnel program the internal flash function of the Pinnacle Plus+ unit. If the unit does not have an AE Bus card installed, the flash port also lets you use a type of AE Bus protocol to communicate with the Pinnacle Plus+ supply. (see “Transmission Parameters” on page 4-45).

Located on the rear panel, the Standard Serial port is a shielded modular jack illustrated on page 4-44. (See also the rear panel illustration at the end of the “Installation” chapter.)

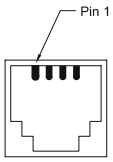

Figure 4-9. *Standard Serial port*

STANDARD SERIAL PORT PIN DESCRIPTIONS

The pin descriptions for this port are as follows.

Table 4-11. *Serial Port Pin Descriptions*

Pin	Description
1	Do *not* connect
2	Power supply transmit
3	Power supply receive
4	Ground

Note: We recommend that for optimal performance, you use only shielded modular cable between the Pinnacle Plus+ unit's Standard Serial port and your host computer.

Transmission Parameters

The communications capability of the Standard Serial port is limited to the following parameters.

Note: These transmission parameters do *not* apply for units with AE Bus cards installed. If your unit has an AE Bus card installed, see the AE Bus section of this manual for more information on transmission parameters.

- RS-232 protocol
- Baud rate of 19.2 kbps
- Pinnacle Plus+ unit address of 1
- Odd parity
- 1 start bit, 8 data bits, one stop bit
- Low-order bytes are transmitted before high-order bytes

Please note that the time-out period for the Pinnacle Plus+ is factory set at 0.02 s (that is, no more than 20 ms can elapse between bytes or the unit will reset and begin looking for a new message packet). This can be changed using command **40** or from the active front panel.

AE BUS (HOST) PORT

Your Pinnacle Plus+ supply features an AE Bus card with a 9-pin, female, subminiature-D connector for interfacing with a host computer. You can do everything from a host computer interfaced with the Pinnacle Plus+ supply that you can do from the active front panel or Pinnacle Plus+ Remote Active Panel.

To obtain a diskette containing sample software with a limited command set, as well as an executable version of the AE Bus software, please call AE Customer Support.

Note: If you have an isolated AE Bus card, your card provides isolation of more than 500 Vrms from the Pinnacle Plus+ unit's SELV logic and control circuitry to all nine pins on the connector.

Make connections for the serial port through its 9-pin, female subminiature-D connector on the rear panel of the unit.

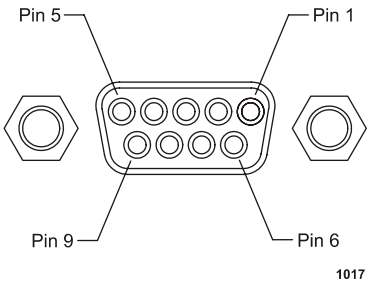

Figure 4-10. *AE Bus port connector*

Pin Descriptions

Refer to the following table for pin descriptions.

Table 4-12. *AE Bus Host Port Pin Descriptions*

Pin	Pin Name	Description
1	*UNASSIGNED*	
2	*TXD.D*	RS-232 transmit data
3	*RXD.D*	RS-232 receive data
4	*UNASSIGNED*	
5	*COM.D*	Data common
6	*TR- / R-*	RS-485 (-) transmit/receive data; RS-422 (-) received data

Table 4-12. *AE Bus Host Port Pin Descriptions (Continued)*

Pin	Pin Name	Description
7	*TR+ / +*	RS-485 (+) transmit/receive data; RS-422 (+) received data
8	*T-*	RS-422 (-) transmit data
9	*T+*	RS-422 (+) transmit data

Transmission Parameters

The communications capability of the serial **AE Bus** port is limited to the following parameters:

- RS-232, RS-422, or RS-485 transmission standard
- Four baud rates (selected by the DIP switch):
  - RS-232: 1200, 4800, 9600, 19,200
  - RS-422, RS-485: 9600, 19,200, 38,400, 57,600
- Odd parity
- 1 start bit, 8 data bits, one stop bit
- Low-order bytes are transmitted before high-order bytes

The time-out period for Pinnacle Plus+ units is factory set at 0.02 s (that is, no more than 0.02 s can elapse between bytes or the unit will reset and begin looking for a new message packet). This can be changed using Command **40**.

The host computer must finish one transaction with a Pinnacle Plus+ unit before it initiates another one, either with the same unit or any other unit.

Note: If you have selected RS-232, the Pinnacle Plus+ unit sends data through pin 2 (*TXD.D)*. This pin must be connected to the receive pin (*RXD.D*) on the host computer's PC serial connector. The receive pin is normally pin 2 for a standard 9-pin PC serial port and normally pin 3 for a standard 25-pin PC serial port.

Note: If you are using RS-422 or RS-485, the Pinnacle Plus+ supply sends and receives data differentially. Thus pin 6 (TR- or R-) and pin 7 (TR+ or R+) are either RS-485 transmit and receiver lines or RS-422 receiver lines. Pins 8 and 9 are RS-422 transmit lines.

Switch Settings

The DIP switch (see Figure 4-11 on page 4-48 and Figure 4-12 on page 4-48) is used to set the AE Bus address for each Pinnacle Plus+ supply in a multi-drop configuration. The DIP switch is located on the rear panel of the Pinnacle Plus+ supply next to the AE Bus port.

There are two types of DIP switches on AE Bus interfaces: “rocker” DIPs and “slide” DIPs (see Figure 4-11 on page 4-48 and Figure 4-12 on page 4-48). Your supply will have one of these types. While the switches on these DIPs are slightly different, they serve the same function. Both DIPs contain eight miniature switches (here called “min-switches”). In all units, setting a switch to the “up” position means setting it toward the numbers on the DIP, and setting a switch to the “down” position means setting it away from the numbers. On “rocker” DIPs, “up” means that the side of the switch toward the numbers is depressed. On “slide” DIPs, “up” means that the slide is pushed toward the numbers.

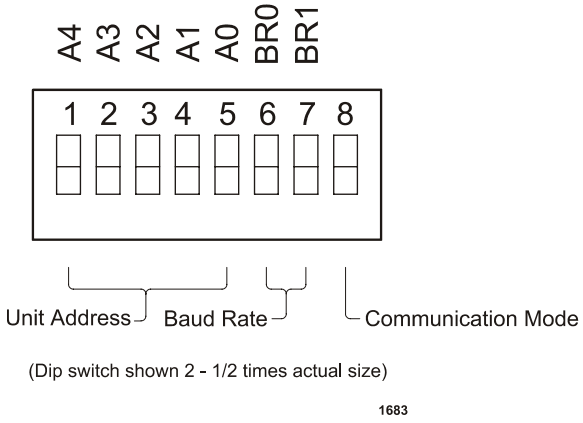

Figure 4-11. *Rocker DIP switch*

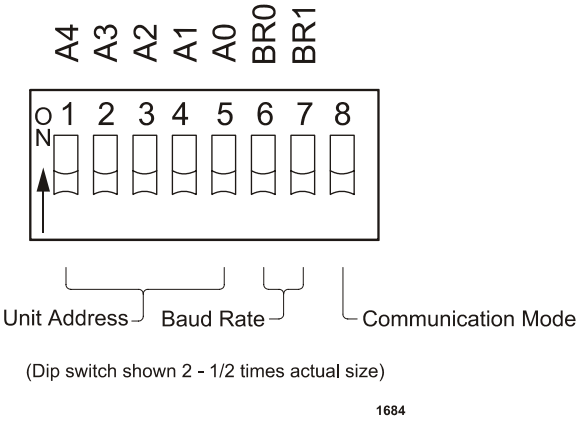

Figure 4-12. *Slide DIP switch*

On units where the DIP switch is located externally on the rear panel, it can be difficult to see the numbers, and the orientation of the unit may change. However, the orientation of the DIP is always the same relative to the unit and, when the unit is

sitting right side up, the numbers are at the top of the DIP. The following illustration shows the orientation of the AE Bus port and DIP switch on the back panel of the Pinnacle supply.

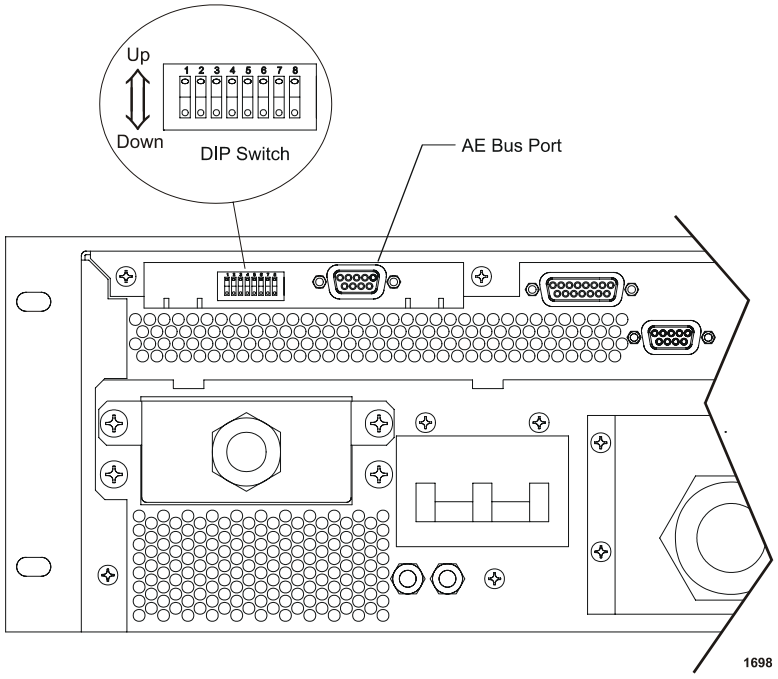

Figure 4-13. *Orientation of the AE Bus port and external DIP switch on the back panel*

The first five min-switches (A4 to A0) are used to specify the address of a Pinnacle Plus+ unit (see Table 4-13 on page 4-51), which a host computer must include in the message packet it sends. Each Pinnacle Plus+ supply in a network must have a unique address.

The next two min-switches (BR1 and BR0) specify the baud rate for the AE Bus port (see Table 4-13 on page 4-51). The last min-switch allows you to choose between RS-232 or differential communication (RS-485 or RS-422). RS-232 is selected when the switch is up. Differential communication is selected when the switch is down.

Note: You must remove the power supply cover to change between RS-422 and RS-485.

DANGER:

Disconnect all sources of input power before working on this unit or anything connected to it. In addition, take proper ESD precautions before removing the unit's top cover to position jumpers.

The mode of differential communication (that is, RS-485 or RS-422) is selected via the jumper labeled as such. You must first remove the unit cover; then place the jumper across pins 1 and 2 for RS-485 (labeled **485**). Place the jumper across pins 2 and 3 for RS-422 (labeled **422**).

If you have selected RS-422 or RS-485, you also have to set two terminator jumpers. If have selected RS-422 or if your Pinnacle Plus+ unit is the last device on an RS-485 multi-drop chain, place the jumpers across pins 1 and 2 (labeled **Term**.). If you have selected RS-485 and your Pinnacle Plus+ unit is not the last device on a multi-drop chain, place the jumpers across pins 2 and 3 for no termination.

SETTING THE PINNACLE PLUS+ UNIT'S AE BUS ADDRESS

Use the DIP switch (see Figure 4-11 on page 4-48 and Figure 4-12 on page 4-48) to set the unit's AE Bus address (see Table 4-13 on page 4-51).

- For units with a single output, an allowable address is between 1 and 31.
- For units with a dual output, the address switches pertain to Side A. Side B is addressed by adding 15 to the address of Side A. Allowable addresses for Side A are 1 to 15. Side B addresses will then be 16 to 30 respectively.
- For units with a dual output and two AE Bus cards—one AE Bus card in the **Serial** port and one AE Bus card in the **User** port—you set the AE Bus address as you would for a dual output. The address switch on both cards pertains to Side A, and Side B is addressed by adding 15 to the address of Side A.

  Note: You can set both addresses on each card to be the same address for side A, or have two different addresses for side A (as shown in the example below).

  For example:

  - For the AE Bus card in the **Serial** port, you set the address switch for Side A to *3*. If you communicate to this card at address *3*, you control Side A of the unit. If you communicate to this card at address *18*, you control Side B.
  - For the AE Bus card in the **User** port, you set the address switch for Side A to *1*. If you communicate to this card at address *1*, you control Side A of the unit. If you communicate to this card at address *16*, you control Side B.

Table 4-13. *AE Bus Address Settings*

Address	A4	A3	A2	A1	A0
0	Don't assign this address to a unit; it is the AE Bus broadcast address—all Pinnacle Plus+ units receive a message sent to this address by the host, but will not reply.				
1	up	up	up	up	down
2	up	up	up	down	up
3	up	up	up	down	down
4	up	up	down	up	up
5	up	up	down	up	down
6	up	up	down	down	up
7	up	up	down	down	down
8	up	down	up	up	up
9	up	down	up	up	down
10	up	down	up	down	up
11	up	down	up	down	down
12	up	down	down	up	up
13	up	down	down	up	down
14	up	down	down	down	up
15	up	down	down	down	down
16	down	up	up	up	up
17	down	up	up	up	down
18	down	up	up	down	up
19	down	up	up	down	down
20	down	up	down	up	up
21	down	up	down	up	down
22	down	up	down	down	up
23	down	up	down	down	down
24	down	down	up	up	up
25	down	down	up	up	down
26	down	down	up	down	up
27	down	down	up	down	down
28	down	down	down	up	up

Table 4-13. *AE Bus Address Settings (Continued)*

Address	A4	A3	A2	A1	A0
29	down	down	down	up	down
30	down	down	down	down	up
31	down	down	down	down	down

SETTING BAUD RATES AND COMMUNICATION MODE

Also use the DIP switch (see Figure 4-11 on page 4-48 and Figure 4-12 on page 4-48) to set the baud rate for the AE Bus port. The following tables show the DIP switch settings for BR0, BR1, and Switch 8. Switch 8 sets the supply to either RS-232 or RS-485/422. Switches BR0 and BR1 set the baud rates.

Table 4-14. *Setting Switch 8*

Switch Position	Communication Mode
Up	RS-232
Down	RS-485/422

Table 4-15. *Baud Rate Settings*

Baud Rate RS-232	Baud Rate RS-485/422	BR0	BR1
1200	9600	up	up
4800	19,200	up	down
9600	38,400	down	up
19,200	57,600	down	down

AE BUS COMMUNICATIONS

The following sections describe communications between a host and the Pinnacle Plus+ supply.

AE Bus Protocol

The AE Bus protocol uses pure binary data (nothing is coded ASCII) and is designed to facilitate direct communications between a host computer and the Pinnacle Plus+ power supply.

The AE Bus message packet combines chunks of information in such a way that much information can be sent over communication lines at one time. Five types of information (or “Fields”) make up message packets (Figure 4-14):

- Header (address and length of data field)
- Command (see the command list later in this chapter)
- Optional length byte
- Data
- Checksum (error checking)

Figure 4-14 shows the organization of these fields in the AE Bus message packet. The subsequent paragraphs describe each field.

Note: The message packet features this structure whether the message originates at the host computer (master node) or the Pinnacle Plus+ unit.

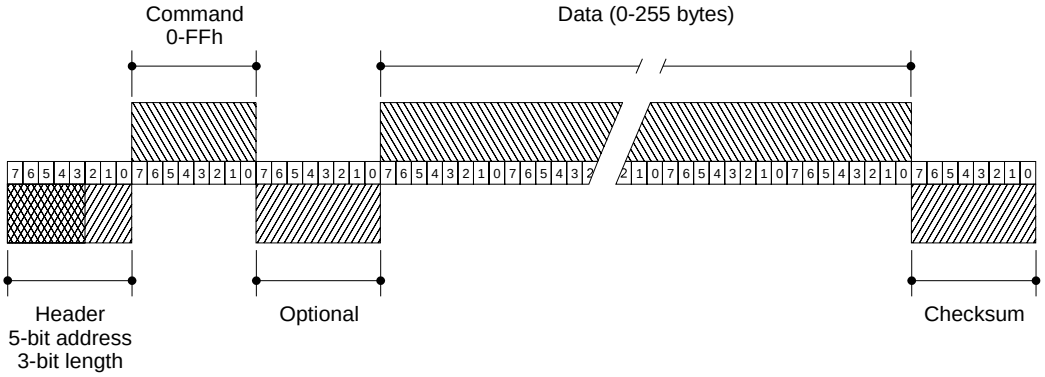

Figure 4-14. *Graphic representation of an AE Bus message packet*

HEADER

The first byte in each packet contains two pieces of information: five bits contain the packet address, and three bits contain the data byte count. If the message packet originates with the host computer (master), the address specifies the packet's destination (to a Pinnacle Plus+ unit, for example). If the packet is going to the host, the address specifies the packet's origin (from the Pinnacle Plus+ unit). The address section of the Header field is five bits long, which allows a total of 32 distinct

addresses. Address 0 (zero) is reserved for the AE Bus broadcast address; when this address is used in a host-originated packet, all units execute the packet (but do not respond back to the host).

The remaining three bits tell the receiving unit how long the Data field is so that the unit can determine when the entire message has been received.

Note: The value in these bits should refer only to the number of actual data bytes. Do not include the checksum byte when calculating the value for these bits.

The Header field (address and length) must be at the beginning of the message packet so that the receiving unit can compute the length of the packet after receiving the first byte.

COMMAND

This field contains a one-byte value: 00h to FFh (0 to 255). If the message packet originates with the host computer, this value specifies the purpose of the message packet. If the message originates with the Pinnacle Plus+ unit, the value specifies the command to which it is responding. See “AE Bus Commands” on page 4-58 for a complete list of AE Bus commands.

OPTIONAL LENGTH BYTE

This field supplements the Header field and exists only when the length bits in the Header field contain a value of 7. Under those circumstances, the Optional field contains a value only when the length bits in the Header field contain a value of 7. (A value of 7 indicates that the Data field contains more than 6 bytes of data.) Under those circumstances, the Optional field contains a one-byte value (between 0 and 255) indicating the number of data bytes.

DATA (DATA BYTES)

The Data field can contain from 0 to 255 bytes of binary data, which are interpreted in various ways, depending on the value that appears in the Command field. The Data field typically contains data or a CSR (see “Creating an Ideal AE Bus Communications Transaction” on page -55), depending on what was requested. Since some commands do not require data, sometimes the Data field is not present.

If the value specified in the length bits of the Header field is 0 to 6, the Pinnacle Plus+ unit expects 0 to 6 bytes of data. However, if the value in the Header field is 7, the Pinnacle Plus+ unit looks for an additional eight-bit byte after the Command field (the Optional field) and uses this value for the data byte count.

CHECKSUM

This one-byte field is the last one in the packet. The content depends on the value of each of the preceding fields. The transmitting unit determines this value by accumulating the XOR (exclusive-or) of all bytes of the packet up to, but not including, the checksum value. The receiving unit accumulates the XOR of all bytes of the packet, including the checksum. If the result is zero, the packet has likely been received intact.

Only after the checksum of a message packet is validated (having no parity errors, and the address is valid) will the Pinnacle Plus+ unit act on the message (which consists of the contents of the command, and if appropriate, the data fields).

Creating an Ideal AE Bus Communications Transaction

The figure below is a simplified graphic showing the steps in an ideal communications transaction between a host computer and a Pinnacle Plus+ unit.

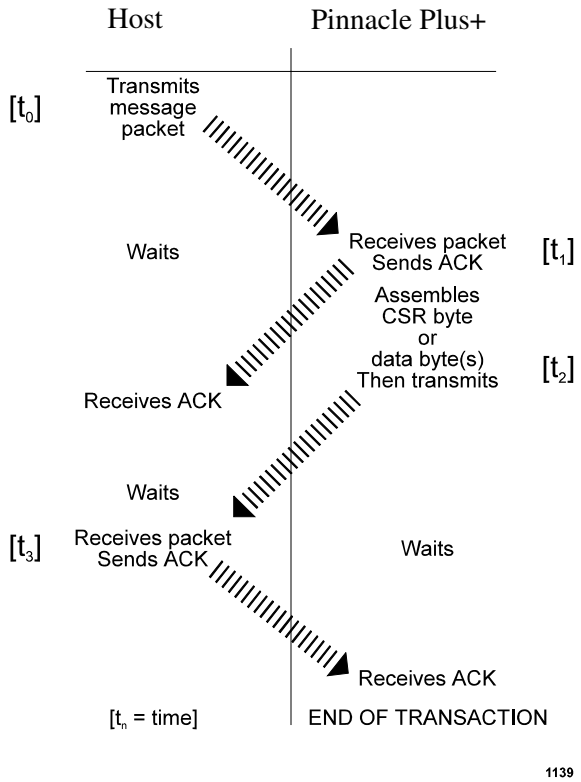

Figure 4-15. *AE Bus communications transaction*

First, the host computer sends a message packet to the Pinnacle Plus+ unit. The packet contains one of the following:

- A command that requests data or status information
- A command and data that change a parameter setting
- An executable command

Once the Pinnacle Plus+ unit receives the message packet, the Pinnacle Plus+ unit verifies that the message is intended for it and not for another unit in the network. At this time, the Pinnacle Plus+ unit also analyzes the checksum to verify that the message was received correctly.

If the address does not match, the Pinnacle Plus+ unit does not respond to the host; the Pinnacle Plus+ unit resets and resumes waiting for a message addressed to it. If the address is correct but the exclusive-or sum of the bytes in the packet (including the checksum) is not zero, the Pinnacle Plus+ unit sends a NAK (negative acknowledgment, hex code 15h) to the host. If the address matches and the message is intact, the Pinnacle Plus+ unit sends an ACK (acknowledgment, hex code 06h) to the host.

If the Pinnacle Plus+ unit receives a request for data or status information, it gathers and sends the requested information. Otherwise, it evaluates the incoming command and sends a message-packet that contains a 1-byte data value (CSR code) to the host (see “Understanding Command Status Response (CSR) Codes” on page -56). CSR code 0 is sent when the command has been accepted.

If the host receives a NAK from the Pinnacle Plus+ unit, the host either re-transmits the packet or does whatever else it has been programmed to do in this situation. If the host receives an ACK, it waits for the requested data or status information or for the CSR code telling it whether or not the new parameter was accepted. If the host receives no response within a reasonable period, it takes whatever action it has been programmed to take.

Meanwhile, the Pinnacle Plus+ unit has prepared a message packet with the requested information or appropriate CSR code, which it then transmits to the host. The host determines by means of the checksum if the message is complete. If the host detects an error in the transmission (by using the Checksum), it can request the packet be sent again by transmitting a NAK.

If the Pinnacle Plus+ unit receives an ACK, it returns to the normal waiting state. If the Pinnacle Plus+ unit receives a NAK, it re-transmits the message packet. The Pinnacle Plus+ unit continues to re-transmit in response to NAK transmissions until the host stops the cycle. If the Pinnacle Plus+ unit receives no response, it assumes an ACK and returns to the waiting state.

Understanding Command Status Response (CSR) Codes

When the Pinnacle Plus+ unit sends a Command Status Response (CSR) code in response to a command, interpret the CSR (a one-byte response) code in the following way:

Table 4-16. *Command Status Response (CSR) Codes*

Code	Meaning
0	Command accepted
The following CSR codes are sent in response to a command that was not accepted and provide an indication of why the command was not accepted.	
1	Control mode is incorrect
2	Output is on, change not allowed
3	Output is off, change not allowed
4	Data is out of range
5	Invalid parameter
6	Program source is incorrect
7	Active fault(s) exist
9	Data byte count is incorrect
10	User port has priority
11	Bus is not ready
12	This feature is not available on your unit
16	Target life has been consumed
17	Output OFF timer active (minimum off time is 50 ms)
19	Recipe is active (change not allowed)
21	Joule set point has not been reached
25	Unit is configured as a slave
28	Set point exceeds user limit
29	Regulation mode is locked (you cannot switch between regulation modes while output power is on)
31	The User port reset is active (you must de-assert the reset line on the User port)
33	Pulsing disabled (frequency = 0)
34	Unit is a Sync Pulse receiver

Table 4-16. *Command Status Response (CSR) Codes (Continued)*

36	User set point out of range
99	Command not accepted (there is no such command)

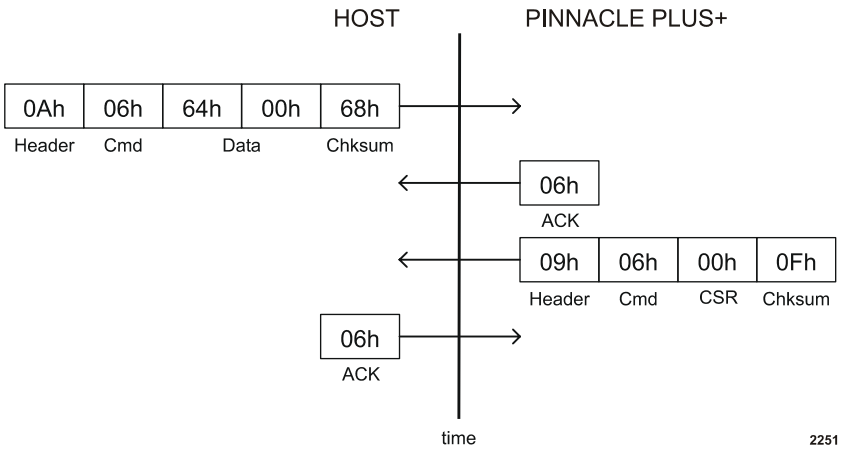

Figure 4-16. *AE Bus communications transaction example*

AE Bus Commands

To operate the power supply from a host computer, you must first set the control mode to host (command **14**).

AE Bus commands **1** through **127** change the value of a parameter or direct the power supply to perform a specific function. The Pinnacle Plus+ supply responds to these commands with a CSR code (see “Understanding Command Status Response (CSR) Codes” on page 4-56). The codes returned in response to each of these commands is listed in the rightmost column of the table.

Commands **128** through **255** request a value to be read from the Pinnacle Plus+ supply. The number of data bytes contained in the return packet is listed in the rightmost column of the table. Some of these commands may return CSR codes; those codes are listed in the same column.

Table 4-17. *AE Bus Commands*

Command	Description	Number of Transmit Data Bytes	CSR Codes or Number of Response Bytes
0 **null off**	Null command.	0	CSR Codes: 0,9
1 **DC off**	Sets DC output off; this request is always honored, regardless of which interface has control.	0	CSR Codes: 0, 9
2 **DC on**	Sets DC output on; host control mode must be selected (see command **14**). Read back the status of the last output on event with command **161**.	0	CSR Codes: 0,1,2,7,9,16 17,31
3 **regulation method**	Sets the method of output regulation (power, current or voltage). Send 1 data byte (8-bit value): • 6 = Power • 7 = Voltage • 8 = Current *Note:* Output power must be off (that is, output must be deenergized) to switch between regulation modes. Read back this value with command **154**.	1	CSR Codes: 0,1,2,5, 9,29
4 **joule set point**	Specifies the number of joules to be delivered. Send a 4-byte (32-bit value); the value must be between 0 and 9,999,999. Read back this value with command **173**.	4	CSR codes: 0,1,4,9
5 **joule mode enable**	Enables or disables joule mode. Send 1 data byte (8-bit value): • 0 = Disable • Non-zero value = Enable Read back this value with command **153**.	1	CSR codes: 0,1,2,9

Table 4-17. *AE Bus Commands (Continued)*

Command	Description	Number of Transmit Data Bytes	CSR Codes or Number of Response Bytes
6 **set point**	Specifies the output set point level for whichever method of regulation mode has been selected. Send 2 data bytes (16-bit value); an output power value implies 3 decimal places for a stand-alone unit and 2 decimals for a master/ slave unit. An output current value should imply 2 decimal places, and an output voltage value should imply 0 decimal places. For example, for a 6 kW, standard Z stand-alone supply, send a value between 0 and 6000 (6.000 kW, decimal is implied), or 0 and 1500 (15.00 A, decimal is implied), or 0 and 800 (maximum output voltage). Please refer to the “Specifications” chapter of this manual for your unit's capabilities. *Note:* If the ramp feature is enabled (commands **15** and **16**), sending this command while the output is on will force the unit to ramp from the existing set point to the new requested set point over the time specified in command **16**. Thus, by using this command and commands **15** and **16**, you can generate an output wave form during a process. Read back this value with command **164**.	2	CSR Codes: 0,1,4,6,9 19

Table 4-17. *AE Bus Commands (Continued)*

Command	Description	Number of Transmit Data Bytes	CSR Codes or Number of Response Bytes
8 **arc shutdown time**	Send 2 data bytes to set the arc shutdown time. • Byte 1 = Unused • Byte 2 = Send the appropriate value below indicating the arc shutdown time (in µs). ▸ 0 = 200 ▸ 1 = 500 ▸ 2 = 1000 ▸ 3 = 1500 ▸ 4 = 2000 ▸ 5 = 2500 ▸ 6 = 3000 ▸ 7 = 4000 ▸ 8 = 5000 Readback this value with command **170**.	2	CSR only
9 **hard arc count limit**	Sets the number of hard arcs required for the power supply to provide an arc indication. (If the limit is reached during a process cycle, then after output shuts off, the ARC LED on the passive panel or active control panel lights and, if applicable, a pulse is sent to the User port *ARC.D* output signal. For more information, see “I/O Communication and Control” on page -1 . Send 4 data bytes (a 32-bit value) indicating the number of arcs; the value must be at least 0 but no greater than the maximum set for your unit. *Note:* If you set the hard arc count limit to 0, each time a hard arc occurs the ARC LED lights for a predetermined time and, if applicable, a signal is sent to the User port. Read back this value with command **178**.	4	CSR codes: 0,1,4,9

Table 4-17. *AE Bus Commands (Continued)*

<table>
<tr><th>Command</th><th>Description</th><th>Number of Transmit Data Bytes</th><th>CSR Codes or Number of Response Bytes</th></tr>
<tr><td>10

voltage arc trip level</td><td>Specifies the voltage level at which the unit indicates an arc is occurring. Sixteen discrete levels are available. These levels are represented by the index numbers in the following table.

Send one data byte (8-bit value) identifying the appropriate index value for the desired trip level.

<table>
<tr><th>Index (data byte)</th><th>Trip Level (result in volts)</th></tr>
<tr><td>0</td><td>10</td></tr>
<tr><td>1</td><td>20</td></tr>
<tr><td>2</td><td>30</td></tr>
<tr><td>3</td><td>40</td></tr>
<tr><td>4</td><td>50</td></tr>
<tr><td>5</td><td>60</td></tr>
<tr><td>6</td><td>70</td></tr>
<tr><td>7</td><td>80</td></tr>
<tr><td>8</td><td>90</td></tr>
<tr><td>9</td><td>100</td></tr>
<tr><td>10</td><td>125</td></tr>
<tr><td>11</td><td>150</td></tr>
<tr><td>12</td><td>175</td></tr>
<tr><td>13</td><td>200</td></tr>
<tr><td>14</td><td>225</td></tr>
<tr><td>15</td><td>250</td></tr>
</table>

Read back this value with command 171.</td><td>1</td><td>CSR codes: 0,1,4,9</td></tr>
</table>

Table 4-17. *AE Bus Commands (Continued)*

Command	Description	Number of Transmit Data Bytes	CSR Codes or Number of Response Bytes
11 **active target**	Specifies which target will be active. Send 1 data byte (8-bit value); the value must be at least 1 but no greater than 8. *Note:* The User port has priority for target selection. Thus to select targets from the active front panel or from the Pinnacle Remote Panel (that is, when the Pinnacle Plus+ unit is in local or host control mode), you must set the target to 1 at the User port. Leaving the target bits open or leaving the User port pins unconnected causes the target selection at the User port to default to 1. Read back this value with command **156**.	1	CSR codes: 0,1,2,4,9,10
12 **target life**	Sets the life (in kilowatt-hours) of the target you specify. Send 1 data byte (8-bit value) plus 4 data bytes (32-bit value), arranged as follows: • First byte = Target number • Second/third/fourth/fifth bytes = Target life (in kilowatt-hours); two decimal places are implied (that is, to get 1 kW, send a value of 100). Read back this value with command **157**.	5	CSR codes: 0,1,2,4,9
13 **target enable**	Enables or disables the target life counter. Send 1 data byte (8-bit value): • 0 = Inactive • Non-zero value = Target life is active Read back this value with command **163**.	1	CSR codes: 0,1,2,9

Table 4-17. *AE Bus Commands (Continued)*

Command	Description	Number of Transmit Data Bytes	CSR Codes or Number of Response Bytes
14 **control mode**	Chooses the mode of control for the Pinnacle Plus+ supply. Send 1 data byte: • 2 = Serial (Host) port • 4 = User port • 6 = Active control panel Read back this value with command **155**.	1	CSR codes: 0,2,5,9,12
15 **ramp enable**	Enables or disables the ramp feature. Send 1 data byte (8-bit value): • 0 = Disable • Non-zero = Enable Read back this value with command **163**.	1	CSR codes: 0,1,2,9,19
16 **ramp time**	Sets the ramp time in 10 ms increments. Range is 50 ms to 600.00 s. Send a 2-byte value between 5 and 60,000. Two decimal places are implied. (To get 1 s, send a value of 100.) *Note:* If your unit has 100 ms ramp feature enabled, one decimal is implied. The range is 0.5 s to 6000.0 s. Read back this value with command **158**.	2	CSR codes: 0,1,4,9

Table 4-17. *AE Bus Commands (Continued)*

Command	Description	Number of Transmit Data Bytes	CSR Codes or Number of Response Bytes
17 **program source**	Tells the Pinnacle Plus+ supply whether the source of information for regulation mode and set points is internal or external (the source can be set independently for each of the three control modes). Send 3 data bytes, arranged as follows: • First byte = Program source—if the serial (Host) port is active • Second byte = Program source—if a control panel is the active interface • Third byte = Program source—if the User port is active For each mode, send an 8-bit value as follows: • 0 = Program source is internal • Non-zero value = Program source is external (that is, an analog value from the User port) *Note:* A User card must be installed for this feature to be available. Read back these values with command **163**.	3	CSR codes: 0,1,2,9
19 **recipe steps**	Specifies the number of recipe steps in your recipe. Send 1 data byte (8-bit value); the value must be at least 0 but no greater than 8. A value of 0 disables the recipe feature. *Note:* For each recipe step, you must also set the regulation mode, set point, ramping time, and run time (commands **21**, **22**, and **23**). Read back this value with command **180**.	1	CSR codes: 0,1,2,4,9

Table 4-17. *AE Bus Commands (Continued)*

Command	Description	Number of Transmit Data Bytes	CSR Codes or Number of Response Bytes
21 **recipe ramp time**	Specifies the length of ramping time for a recipe step (that is, how long the unit will take to reach the set point you have defined for the selected recipe step). Send three data bytes arranged as follows: • First byte = Recipe step (must be a value between 0 and 8) • Second and third bytes = Value between 0 and 60,000 (or between 0 s and 600 s); two decimal places implied. *Note:* If your unit has 100 ms ramp feature enabled, one decimal is implied. The range is 0 s to 6000.0 s. Read back these values with command **181**.	3	CSR codes: 0,1,2,4,9
22 **recipe set point**	Specifies the set point for a recipe step. Send three data bytes arranged as follows: • First byte = Recipe step (must be a value greater than 0 but no greater than 8) • Second and third bytes = Value between 0 and the full rated output of the supply. *Note:* See the "Specifications" chapter for your unit's capabilities, and see command **6** for the format of the value. Read back these values with command **182**.	3	CSR codes: 0,1,2,4,9

Table 4-17. *AE Bus Commands (Continued)*

Command	Description	Number of Transmit Data Bytes	CSR Codes or Number of Response Bytes
23 recipe run time or joule set point	Specifies the length of time the unit will run at set point for a recipe step. If you enable joule recipe, use this command to set the joule set point. Send 3 data bytes arranged as follows: • First byte = Recipe step (value must be greater than 0 but no greater than 8) *Note:* When joule recipes are enabled, recipe step numbers 1 through 8 use the value in the second and third bytes to set the LSW of the joule set point. Step numbers 129 through 136 set the MSW of the joule set point, where step 129 sets MSW of step 1, step 130 sets MSW of step 2, and so on. When command 23 is sent with step numbers 1 through 8, the MSW is cleared. To set joule set points greater than 65535, first send command 23 with steps 1 through 8, then send command 23 with steps 129 through 136. • Second and third bytes = Value between 0 and 60,000 (or between 0 and 600 s); two decimal places implied. *Note:* If you assign 0 run time for the final recipe step, the unit will switch to continuous output when it reaches set point for this step. In this situation, to turn off output, you must send an off command (using the OFF button or the appropriate User port signal or serial port command) or you must have already enabled joule mode and programmed a joule set point. Read back these values with command **183**.	3	CSR only

Table 4-17. *AE Bus Commands (Continued)*

Command	Description	Number of Transmit Data Bytes	CSR Codes or Number of Response Bytes
24 **calculate logic CRC**	Tells the Pinnacle Plus+ supply to calculate its logic CRC. *Note:* During the approximately 2 seconds it takes to calculate the CRC, the Pinnacle Plus+ unit will not respond to any other commands. Read this value back with command **230**.	0	CSR codes: 0,2,9
26 **joule threshold**	Specifies the output level that needs to be met before the Joule output energy calculation begins (the joule threshold). The joule threshold type (power, voltage, or current) is set with command **64**. If the threshold type is set in Watts, send 2 bytes (16-bit value) between 10 and maximum power divided by 8. This value represents watts in a stand-alone system and decawatts in a master/slave system. For threshold types set in Volts or Amps, send 2 bytes (16-bit value) between 0 and the maximum output limit. *Note:* The Joule energy calculation begins after (n) mS, regardless of the output level. The time value, (n) mS, is set in the configuration and cannot be changed. If the output level meets the joule energy threshold prior to the time expiration, the joule energy calculation will begin. Read back this value with command **136**.	2	0, 1, 2, 4, 9

Table 4-17. *AE Bus Commands (Continued)*

Command	Description	Number of Transmit Data Bytes	CSR Codes or Number of Response Bytes
31 **out-of-set point timer**	Enables or disables an out-of-set point timer and specifies how long you want the power supply to tolerate an out-of-set point condition before shutting off output. • To enable the timer, send a value (2 bytes) between 1 and 9999 (0.1 to 999.9 s). • To disable the timer, send a value of 0. Read back this value with command **187**.	2	CSR codes: 0,1,4,9
32 **ramp start point (percentage of set point)**	Sets the ramp start point as a percentage of set point when output is turned on. The range is 0 to 95%. Send a 1 byte value of 0 to 95. Read back this value with command **152**.	1	CSR codes: 0,1,4,9
33 **recipe type**	Set the type of recipe. The default is “Timed.” Send 1 data byte: • 1 = Timed • 2 = Joule continuous • 3 = Joule discrete Read back with command **196**.	1	CSR only
34 **over-voltage timer**	Enables or disables an over-voltage timer and specifies how long you want the power supply to tolerate an over-voltage condition before shutting off output. • To enable the timer, send a value (2 bytes) between 1 and 9999 (0.1 to 999.9 s) • To disable the timer, send a value of 0 Read back with command **174**.	2	CSR codes: 0,1,4,9

Table 4-17. *AE Bus Commands (Continued)*

Command	Description	Number of Transmit Data Bytes	CSR Codes or Number of Response Bytes
35 **over-current timer**	Enables or disables an over-current timer and specifies how long you want the power supply to tolerate an over-current condition before shutting off output. • To enable the timer, send a value (2 bytes) between 1 and 9999 (0.1 to 999.9 s) • To disable the timer, send a value of 0 Read back with command **186**.	2	CSR codes: 0,1,4,9
36 **constant duty cycle**	Enables or disables the constant duty cycle feature. Send 1 byte: • 0 = Disable • Non-zero = Enable Read back with command **163**.	1	CSR codes: 0,1,9
38 **reset arc density/run counters**	Resets micro-arcs-per-run and hard-arcs-per-run counters to 0. These counters can be reset at any time, and resetting them can be useful for measuring arcs over a specific period of time.	0	CSR codes: 0,1,9
40 **AE Bus time-out value**	Specifies the amount of time the Pinnacle Plus+ supply waits between bytes from the host. Send 2 data bytes (16-bit value); the value represents increments of 10 ms and must be at least 2 but no greater than 500 (20 ms to 5 s). That is, two decimal places are implied (enter 500 for 5.00). Read back this value with command **140**.	2	CSR codes: 0,1,4,9

Table 4-17. *AE Bus Commands (Continued)*

Command	Description	Number of Transmit Data Bytes	CSR Codes or Number of Response Bytes
43 **sets synch pulse as transmitter or receiver**	Sets the unit's synch pulse feature as a transmitter or a receiver. Send 1 data byte: • 0 = Receiver • Non-zero = Transmitter Read back with command **163**.	1	CSR codes: 0,1,2,9
44 **panel text line 1**	Lets you write up to 40 characters of text to line one (top line) of an active control panel	0 to 40	CSR codes: 0,9
45 **panel text line 2**	Lets you write up to 40 characters of text to line two (bottom line) of an active control panel.	0 to 40	CSR codes: 0,9
46 **erase panel text**	Erases text displayed with commands **44** and **45** and refreshes the display.	0	CSR codes: 0,9
You may set values for all three user output limits (commands **49**, **50**, and **51**); however, the Pinnacle Plus+ unit responds to the first limit value that impacts output.			

Table 4-17. *AE Bus Commands (Continued)*

Command	Description	Number of Transmit Data Bytes	CSR Codes or Number of Response Bytes
49 **user power limit**	Sets a maximum limit for output power. Send 2 data bytes (16-bit value); value must be between 0 and the maximum rated output power for the supply. 3 decimal places are implied for a stand-alone unit (10000 = 10.000 kW) and 2 decimal places are implied for a master/slave system (2000 = 20.00 kW). *Note:* You cannot change the power limit when output is on because this limit is used to establish the type of operation: low or high power. For values of 10% of the full power or less, the operation mode is low; for values greater than 10% of full power the operation mode is high. (See Chapter 6, "Operation," for more information). Read back this value with command **141**.	2	CSR codes: 0,1,4,9
50 **user voltage limit**	Sets a maximum limit for output voltage as measured at the DC inverter output (see Figure 2-1 on page 2-2). Send 2 data bytes (16-bit value); value must be between 0 and the maximum rated output voltage for the supply. Read back this value with command **142**.	2	CSR codes: 0,1,4,9
51 **user current limit**	Sets a maximum limit for output current. Send 2 data bytes (16-bit value); value must be between 0 and the maximum rated output current for the supply. Assume 2 decimal places (5000 = 50.00 A). Read back this value with command **143**.	2	CSR codes: 0,1,4,9

Table 4-17. *AE Bus Commands (Continued)*

Command	Description	Number of Transmit Data Bytes	CSR Codes or Number of Response Bytes
59 **joule recipe repetition**	Send 2 data bytes (16-bit value). Valid input for the joule recipe repetitions are 1 through 65535. *Note:* This command is only valid when you set the continuous joule recipe type. Readback this value with command **233**.	2	CSR only
61 **enable/ disable micro arc handling**	Enables or disables micro arc handling feature. Hard arc handling is always enabled. Send 1 data byte (8-bit value): • 0 = Disable • Non-zero = Enable *Note:* Cycling power to the unit resets arc handling mode to enabled. Read this value with command **163**.	1	CSR codes: 0,1
64 **threshold type**	Sets the joule mode counter threshold type. Send one data byte (8-bit value): • 0 = Power • 1 = Voltage • 2 = Current Read back this setting with command **163**.	1	CSR codes: 0,1,2,4,9
65 **pulsing enabled mode**	Enables pulsing at the current threshold (default setting) or always. *Note:* Frequency is limited to 150 kHz when the pulse mode is set to be enabled always. Send one data byte (8-bit value): • 0 = Pulsing enabled at current threshold • 1 = Pulsing enabled always Read back this setting with command **163**.	1	CSR codes: 0,1,2,4,9

Table 4-17. *AE Bus Commands (Continued)*

Command	Description	Number of Transmit Data Bytes	CSR Codes or Number of Response Bytes
66 **enable or disable hard-arc broadcast**	Enable or disable the hard-arc broadcast feature. Send 1 data byte: • 0 = Disable • Non-zero = Enable Read back this setting with command **163**.	1	CSR codes: 0,1,2,9
72 **near end (joule) indication**	Set a joule value to indicate the joule down counter is near expiration. Send 2 data bytes (16-bit value). Read back this setting with command **232**.	2	CSR only
73 **joule count reset**	Resets the joules remaining counter to its initial value while the output is on.	0	CSR only
74 **enable/ disable joule countdown**	Enable or disable the joule countdown feature, which waits for command **73** before beginning the joule countdown. Send 1 data byte: • 0 = Disable • Non-zero = Enable Read back this setting with command **163**.	1	CSR only
84 **redefine PROFIBUS status bits**	Redefines the PROFIBUS status bits. Send 1 data byte: • 0 = Normal format • Non-zero = Joule recipe definition	1	CSR only

Table 4-17. *AE Bus Commands (Continued)*

Command	Description	Number of Transmit Data Bytes	CSR Codes or Number of Response Bytes
85 **change configuration option bit**	Changes the configuration option bit. Requires 2 data bytes. 1st data byte - Bit setting: • 0 = Clear bit • Non-zero = Set bit 2nd data byte - Configuration option bit number (valid entries = 0-31): • 7 = RAMP RESOLUTION • 8 = JOULE RECIPE STATUS • 18 = USER-PORT EOTL DEFINED AS READY SIGNAL • 19 = HIGH SPEED AEBUS • 25 = EXPLICIT FAULT CLEARING	2	CSR only
92 **pulse frequency index**	Sets pulse frequency from 0 to 350 kHz (in 5 kHz increments): *Note:* Frequency is limited to 150 kHz when the pulse mode is set to be enabled always. • 0 = Pulsing disabled • 1 = 5 kHz • 2 = 10 kHz • 3 = 15 kHz • 4 to 69 = (follow the established pattern) • 70 = 350 kHz Read back this setting with command **146**.	1	CSR codes: 0,1,4,9

Table 4-17. *AE Bus Commands (Continued)*

Command	Description	Number of Transmit Data Bytes	CSR Codes or Number of Response Bytes
93 **pulse reverse time**	Sets pulse reverse time from 0.4 µsto 5.0 µs (in 0.1 µs increments): • 04 = 0.4 µs • 05 = 0.5 µs • 06 = 0.6 µs • 07 to 49 = (follow the established pattern) • 50 = 5.0 µs Read back this setting with command **147**.	1	CSR codes: 0,1,4,9,33
119 **master reset**	Send this command to clear fault indication when the Pinnacle Plus+ supply has experienced a non-recoverable fault. *Note:* Output will be turned off. This request is always honored, regardless of which interface has control.	0	CSR codes: 0,9
126 **reset default settings**	Resets all user-defined values to their factory defaults and stores them in non-volatile memory. Send one data byte with a value of 0.	1	CSR codes: 0,1,2,9
127 **write to scratch pad**	Lets you write up to 40 ASCII characters to a scratch pad memory (non-volatile). Retrieve this information with command **131**.	0 to 40	CSR codes: 0,9
Commands **128** through **255** request a value to be read from the Pinnacle Plus+ unit. Some of these commands may return CSR codes.			
128 **request supply type**	Requests the power supply type; the returning packet contains 4 ASCII characters: “PLUS”.	0	4

Table 4-17. *AE Bus Commands (Continued)*

Command	Description	Number of Transmit Data Bytes	CSR Codes or Number of Response Bytes
129 **request supply size**	Requests the output capacity of the power supply; the returning packet contains 6 characters indicating capacity in kilowatts. The data string implies 3 decimal places for a stand-alone unit (10000 = 10.000 kWh) and implies 2 decimal places for a master/slave system (120000 = 1200.00 kWh).	0	6
130 **request maximum unit limits**	Reports the maximum limits for this unit; the returning packet contains three (16-bit) values for: power, voltage, and current limits.	0	6
131 **request scratch pad memory**	Displays most recent entry (40 characters) to scratch pad memory. Set with command **127**.	0	40
136 **request joule threshold**	Requests the output level that needs to be met before the Joule output energy calculation begins. This level is set with command **26**. The joule threshold type (power, voltage, or current) is set with command **64**.	0	2
140 **request AE Bus time-out value**	Requests the AE Bus time-out value; the returning packet contains 2 data bytes (16-bit value) indicating the time in ms (a value of 2 indicates 20 ms). This value is set with command **40**.	0	2

Table 4-17. *AE Bus Commands (Continued)*

Command	Description	Number of Transmit Data Bytes	CSR Codes or Number of Response Bytes
141 **request user power limit**	Requests the output power limit. Accuracy is +0.3% of the full rated output voltage for the supply. The returning packet contains 2 data bytes (16-bit value) indicating the limit in kilowatts. The value implies 3 decimal places for a stand-alone unit (5000 = 5.000 kW) and 2 decimal places are implied for a master/slave unit (2000 = 20.00 kW). This value is set with command **49**.	0	2
142 **request user voltage limit**	Requests the output voltage limit. Accuracy is +0.3% of the full rated output voltage for the supply. The returning packet contains 2 data bytes (16-bit value) indicating the limit in voltage. This value is set with command **50**.	0	2
143 **request user current limit**	Requests the output current limit. Accuracy is +0.3% of the full rated output current for the supply. The returning packet contains 2 data bytes (16-bit value) indicating the limit in amperes. Assume 2 decimal places (5000 = 50.00 A). This value is set with command **51**.	0	2
146 **request pulse frequency index**	Requests pulse frequency index (read in 5 kHz increments); the returning packet contains 1 byte: • 0 = 0 kHz (pulsing disabled) • 1 = 5 kHz • 2 = 10 kHz • 3 = 15 kHz • 4 to 69 = (follow the established pattern) • 70 = 350 kHz This value is set with command **92**.	0	1

Table 4-17. *AE Bus Commands (Continued)*

Command	Description	Number of Transmit Data Bytes	CSR Codes or Number of Response Bytes
147 **request pulse reverse time**	Requests pulse reverse time (read in 0.1 µs increments); the returning packet contains 1 byte: • 04 = 0.4 µs • 05 = 0.5 µs • 06 = 0.6 µs • 07 to 49 (follow the established pattern) • 50 = 5.0 µs This value is set with command **93**.	0	1
152 **request ramp start set point percentage**	Requests the ramp start set point percentage; returning packet contains 1 data byte (8-bit) between 0 and 95 (%). This value is set with command **32**.	0	1
153 **request joules status**	Requests joule mode status; the returning packet contains 1 byte: • 0 = Inactive • Non-zero value = Active This value is set with command **5**.	0	1
154 **request regulation mode**	Requests the output regulation mode; the returning packet contains 1 data byte (8-bit value): • 6 = Power • 7 = Voltage • 8 = Current *Note:* Output power must be off (that is, output must be deenergized) to switch between regulation modes. This value is set with command **3**.	0	1

Table 4-17. *AE Bus Commands (Continued)*

Command	Description	Number of Transmit Data Bytes	CSR Codes or Number of Response Bytes
155 **request control mode**	Requests control mode; the returning packet contains 1 data byte (8-bit value): • 2 = Serial (Host) port • 3 = Active control panel (Local) • 4 = User port This value is set with command **14**.	0	1
156 **request active target number**	Requests an indication of the active target; the returning packet contains 1 data byte indicating target 1, 2, 3, 4, 5, 6, 7, or 8. This value is set with command **11**.	0	1
157 **request target life**	Requests the amount of target life time remaining for the target you specify. Send 1 data byte indicating which target; the returning packet contains 4 data bytes (32-bit value) indicating the time remaining in kilowatt-hours. Two decimal places are implied. For example, a value of 100 indicates 1 kWh. This value is set with command **12**.	1	4 (May return CSR code 4)
158 **request ramp time**	Requests ramp time. Returns a 2-byte value (16 bits) indicating a ramp time of 5 (50ms) to 60,000 (600.00 s). *Note:* If your unit has 100 ms ramp feature enabled, one decimal is implied. The range is 0.5 s to 6000.0 s. This value is set with command **16**.	0	2
159 **ramp time remaining**	Requests how much ramp time is remaining. Returning packet contains 2 data bytes (16 bits), indicating how many 10 ms intervals remain. *Note:* If your unit has 100 ms ramp feature enabled, the data indicates how many 100 ms intervals remain.	0	2

Table 4-17. *AE Bus Commands (Continued)*

Command	Description	Number of Transmit Data Bytes	CSR Codes or Number of Response Bytes
160 **request status**	Requests the status of the logic board. The information in the returning packet is used by AE Customer Service. The returning packet contains 6 data bytes: 1st and 2nd bytes - SW_OPTS1 (16-bit value): • 0 = Single Inverter Unit (read only) • 5 = 500ns Gate Drive Unit (read only) • 7 = 100 ms ramp; bit clear = 10 ms ramp • 8 = Joule recipe definition; bit clear = normal 3rd and 4th bytes - SW_OPTS2 (16-bit value): • 2 = Redefined as READY signal; bit clear = End of Target Life indicator (EOTL) • 3 = High Speed Baud Rate = 19200, 38400, 57600, 115200; bit clear = normal • 9 = No explicit fault clearing (requires power cycle to clear); bit clear = off and reset command clears fault 5th and 6th bytes: Always 0	0	6

Table 4-17. *AE Bus Commands (Continued)*

Command	Description	Number of Transmit Data Bytes	CSR Codes or Number of Response Bytes
161 **request output on status**	Requests the Control Status Response (CSR) of most recent output on sequence; the returning packet contains 1 data byte (8-bit value): • 0 = Output on sequence OK. • 1 = Control mode invalid • 2 = Unit is already on • 7 = Active fault exists • 11 = Bus is not ready • 16 = End of target life event • 17 = Minimum off time is active • 31 = User port reset line active • 32 = Contactor is open due to a fault condition • 44 = The Pinnacle Plus+ has not received a request to turn output on since power up *Note:* See "Understanding Command Status Response (CSR) Codes" on page 4-56 for more information on CSR codes.	0	1

Table 4-17. *AE Bus Commands (Continued)*

Command	Description	Number of Transmit Data Bytes	CSR Codes or Number of Response Bytes
162 **request process status**	Requests a report on process status; the returning packet contains 4 data bytes: 1st status byte: • 0 = Unassigned • 1 = Ramp active • 2 = Run active • 3 = Output power (0 = off, 1 = on) • 4 = Illegal regulation mode • 5 = Cable interlock • 6 = End-of-target-life event • 7 = Set point status (0 = within tolerance, 1 = out-of-tolerance) 2nd status byte: • 0 = Over-voltage condition exists • 1 = Over-current condition exists • 2 = Unassigned • 3 = Control circuit fault • 4 = Heat sink over-temperature event • 5 = User interlock open • 6 = User port reset active • 7 = Main contactor interlock open 3rd status byte: • 0 = Momentary power failure • 1 = Unassigned • 2 = Near end joule value setting has been reached • 3 = Unassigned • 4 = Side A inverter low • 5 =Side B inverter low • 6 = Unassigned interrupt event • 7 = PROFIBUS error (Continued on next page)	0	4

Table 4-17. *AE Bus Commands (Continued)*

Command	Description	Number of Transmit Data Bytes	CSR Codes or Number of Response Bytes
162 **request process status (continued)**	4th status byte: • 0 = Hard bus fault • 1 = Unassigned • 2 = Joules reached • 3 = Unassigned • 4 = Out-of-set point timer expired • 5 = Ground fault detected (if your Pinnacle Plus+ supports this feature • 6 = Unassigned • 7 = Unassigned	0	4

Table 4-17. *AE Bus Commands (Continued)*

Command	Description	Number of Transmit Data Bytes	CSR Codes or Number of Response Bytes
163 **request config status**	Requests the system configuration status; the returning packet contains 4 data bytes. 1st status byte: • 0 = Host program source (0 = internal, 1 = external) • 1 = Local program source (0 = internal, 1 = external) • 2 = Analog program source (0 = internal, 1 = external) • 3 = Unassigned • 4 = Unassigned • 5 = Unassigned • 6 = Program source (0 = internal, 1 = external) • 7 = Target life status (0 = inactive, 1 = active) 2nd status byte: • 0 = Profibus Status Bit Definition (0 = normal, 1 = Joule Recipe) • 1 = Active control panel access (0 = unlocked, 1 = locked) • 2 = Joule mode (0 = disabled, 1 = enabled) • 3 = Contactor status (0 = open, 1 = closed) • 4 = Unassigned • 5 = Ramp mode (0 = disabled, 1 = enabled) • 6 = Unassigned • 7 = Pulsing enabled (0 = disabled, 1 = enabled) (Continued on next page)	0	4

Table 4-17. *AE Bus Commands (Continued)*

Command	Description	Number of Transmit Data Bytes	CSR Codes or Number of Response Bytes
163 **request config status** **(continued from previous page)**	3rd status byte: • 0 = Synch pulse setting (0 = receiver, 1 = transmitter) • 1 = Over-voltage timer active • 2 = Over-current timer active • 3 = Constant duty cycle active • 4 = Micro arc handling (0 = disabled, 1 = enabled) • 5 = Pulsing enabled (0 = at current threshold, 1 = always) • 6 and 7 = Threshold type (00 = power, 01 = voltage, 10 = current) 4th status byte: • 0 = Hard-arc broadcast (0 = disabled, 1 = enabled) • 1 = Joule countdown hold (0 = disabled, 1 = enabled) • 2 through 7 = Unassigned	0	4
164 **request set point/ regulation mode**	Requests the set point level by whichever method of output regulation has been selected; the returning packet contains 3 data bytes: • First/second byte = Set point level (16-bit value) • Third data byte = Regulation mode (8-bit value) ▸ 6 = Power ▸ 7 = Voltage ▸ 8 = Current *Note:* Output power must be off (that is, output must be deenergized) to switch between regulation modes. These values are set with commands **3** and **6**.	0	3

Table 4-17. *AE Bus Commands (Continued)*

Command	Description	Number of Transmit Data Bytes	CSR Codes or Number of Response Bytes
165 **request actual power**	Requests a snapshot of the output power level at that instant; the returning packet contains 2 data bytes (16-bit value) indicating power level. Assume three decimal places for a stand-alone unit (6000 = 6.000 kWh) and two decimal places for a master/slave unit (2000 = 20.00 kWh). *Note:* Refer to the "Specifications" chapter of this manual for information regarding your unit's capabilities.	0	2
166 **request actual voltage**	Requests a snapshot of the output voltage level at that instant; the returning packet contains 2 data bytes (16-bit value), indicating the voltage level. For example a value of 800 would indicate 800 V (no implied decimal).	0	2
167 **request actual current**	Requests a snapshot of the output current level at that instant; the returning packet contains 2 data bytes (16-bit value). Two decimal places are implied. For example, a value of 1500 indicates 15.00 A.	0	2
168 **request actual power, voltage, current**	Requests a snapshot of the output power, voltage, and current at that instant; the returning packet contains 6 data bytes: • First/second byte = Power level • Third/fourth byte = Voltage level • Fifth/sixth byte = Current level See commands **165**, **166**, and **167** for the format of the reported output values.	0	6
169 **request set points: power, voltage, and current**	Requests the set point levels for power, voltage, and current; the returning packet contains 6 data bytes (three 16-bit values). See commands **165**, **166**, and **167** for the format of the reported set point values.	0	6

Table 4-17. *AE Bus Commands (Continued)*

Command	Description	Number of Transmit Data Bytes	CSR Codes or Number of Response Bytes
170 request arc shutdown	Requests the arc shutdown time. The returning packet contains 2 data bytes. • Byte 1 = Unused • Byte 2 = Index value set with command **8** (refer to command **8** for the shutdown index values).	0	2
171 request voltage arc trip level	Requests the index for the voltage level at which the unit indicates an arc is occurring. For a list of the voltage levels indicated by the index values, see command **10** text. The returning packet contains 1 data byte indicating the trip level index. This value is set with command **10**.	0	1
172 request joules remaining	Requests how many joules remain during a run; the returning packet contains 4 data bytes (32-bit value) indicating the number of joules.	0	4
173 request joules set point	Requests the joules set point; the returning packet contains 4 data bytes (32-bit value) indicating the set point level in joules. This value is set with command **4**.	0	4
174 request over-voltage timer value	Requests the over-voltage timer value; the returning packet contains 2 data bytes (16-bit value) indicating the value. This value is set with command **34**.	0	2
175 request time output on	Requests how much time has elapsed since output power was turned on; the returning packet contains 3 data bytes: • First byte = Number of hours • Second byte = Number of minutes • Third byte = Number of seconds	0	3

Table 4-17. *AE Bus Commands (Continued)*

Command	Description	Number of Transmit Data Bytes	CSR Codes or Number of Response Bytes
178 **request hard arc count limit**	Requests the hard arc count limit; the returning packet contains 4 data bytes (a 32-bit value) indicating the limit. This value is set with command **9**.	0	4
179 **request active recipe step, ramp/ run status, and ramp/run time remaining**	Requests the active recipe step number, the ramp/run status, and the ramp/run time remaining; the returning packet contains 4 or 6 data bytes depending on the recipe type. • First byte = Active recipe step number • Second byte = Ramp/run or recipe type status (1 = ramp, 2 = run, 4 = continuous recipe, 5 = discrete recipe) • Third and fourth bytes = Ramp/run time remaining (in tens of milliseconds, or 0 if a ramp or recipe has run to completion) if timed recipe is running *OR* • Third, fourth, fifth, and sixth bytes = Joules remaining if discrete or continuous joule recipe is running *Note:* If output is shut off either through a fault or an off command, the active recipe step number, ramp/run status, and ramp/run time remaining will all maintain their last value. A subsequent off command will set recipe step number to 1 (or 0 if recipes are not active) and set ramp/run time remaining to 65535 if the time is nonzero. If the run segment of the last recipe step is 0, ramp/run time remaining is set to 65534 and never counts down.	0	4 or 6

Table 4-17. *AE Bus Commands (Continued)*

Command	Description	Number of Transmit Data Bytes	CSR Codes or Number of Response Bytes
180 **request recipe steps**	Requests the number of recipe steps; the returning packet contains 1 data byte (8-bit value) indicating the number of steps. *Note:* Recall that a value of 0 sent with command **19** disables the ramping recipe feature. This value is set with command **19**.	0	1
181 **request recipe step ramp time**	Requests the amount of ramping time you have set for a specific ramping recipe step. Send 1 data byte (8-bit value) indicating the recipe step. The returning packet contains 2 data bytes (16-bit value) indicating the time in seconds. Two decimal places are implied. For example, a value of 5 would indicate 0.05 s. This value is set with command **21**.	1	2 (May return CSR code 4)
182 **request recipe step set point and regulation mode**	Requests the set point level you have set for a specific ramping recipe step. Send 1 data byte (8-bit value) indicating the recipe step. The returning packet contains 3 data bytes: • First and second bytes = Value of set point in the mode indicated • Third byte = Regulation mode ▸ 6 = Power ▸ 7 = Voltage ▸ 8 = Current This value is set with command **22**.	1	3 (May return CSR code 4)

Table 4-17. *AE Bus Commands (Continued)*

Command	Description	Number of Transmit Data Bytes	CSR Codes or Number of Response Bytes
183 **request recipe step run time or joule set point**	Requests the run time you set for a specific recipe step or, if joule recipe is enabled, this command requests the joule set point. Send 1 data byte (8-bit value) indicating the recipe step. The returning packet contains 2 data bytes indicating the run time in seconds. Or, if joule recipe is enabled, returns 4 data bytes (32-bit value) indicating the joule set point. With timed recipes, two decimal places are implied. For example, a value of 5 would indicate 0.05 s. This value is set with command **23**.	1	2 or 4 (May return CSR code 4)
184 **request out-of-set point interval**	Requests the amount of time remaining on the out-of-set point timer before an error condition occurs; the returning packet contains 2 data bytes (16-bit value) indicating the interval value in seconds. One decimal place is implied. For example a value of 999 would indicate an interval of 99.9 s.	0	2
186 **request over-current timer value**	Requests the over-current timer value; the returning packet contains 2 data bytes (16-bit value) indicating the value. This value is set with command **35**.	0	2
187 **request out-of-set point timer**	Requests the out-of-set point timer value; the returning packet contains 2 data bytes (16-bit value) indicating the timer value in seconds. One decimal place is implied. For example, a value of 999 would indicate a timer value of 99.9 s. This value is set with command **31**.	0	2

Table 4-17. *AE Bus Commands (Continued)*

Command	Description	Number of Transmit Data Bytes	CSR Codes or Number of Response Bytes
188 **arc density per second**	Requests the arc density that occurred in the previous second; returning packet contains 4 data bytes. • First/second byte = Micro arcs (16-bit value) • Third/fourth bytes = Hard arcs (16-bit value)	0	4
189 **request micro arc density**	Requests how many micro arcs occurred in the previous run; returning packet contains 4 data bytes (32-bit value) indicating the number of micro arcs in the previous run. *Note:* The unit records a micro arc each time the output voltage goes below the voltage arc trip level set with command **10**. All arc counters are updated every 100 ms or 10 times per second.	0	4
190 **request hard arc density**	Requests how many hard arcs occurred in the previous run; returning packet contains 4 data bytes (32-bit value) indicating the number of hard arcs in the previous run. *Note:* The unit records a hard arc every time the output voltage goes below the voltage arc trip level for longer than the arc detect time. The unit then shuts down for the arc shutdown time period. All arc counters are updated every 100 ms or 10 times per second.	0	4

Table 4-17. *AE Bus Commands (Continued)*

Command	Description	Number of Transmit Data Bytes	CSR Codes or Number of Response Bytes
195 **request personality card**	Requests the identity of the unit's personality cards. The returning packet contains 2 data bytes: • First byte = Identity of card in slot 1: ◗ 0 = Card not present ◗ 01 or 17 = Dual User port ◗ 03 or 26= PROFIBUS ◗ 05 or 21 = Single User port ◗ 18 or 28 = AE Bus ◗ 23 or 30 = DeviceNet • Second byte = Identity of card in slot 2: ◗ 0 = Card not present ◗ 03 or 26 = PROFIBUS ◗ 04 = Host Protocol Translator ◗ 05 or 21 = Single User port ◗ 18 or 28 = AE Bus ◗ 22 or 29 = Master/slave card with AE Bus	0	2
196 **request recipe type**	Requests the recipe type set with command **33**. Returns 1 data byte. • 1 = Timed • 2 = Joule continuous • 3 = Joule discrete	0	1
197 **request flash configuration**	Requests the version level of the unit's flash memory; returning packet contains 32 data bytes.	0	32
198 **request s/w rev level—mainframe**	Requests the revision level of the mainframe software; the returning packet contains 11 ASCII characters.	0	11

Table 4-17. *AE Bus Commands (Continued)*

Command	Description	Number of Transmit Data Bytes	CSR Codes or Number of Response Bytes
208 request fault list	Returns a list of fault codes representing active faults affecting the unit. Send 1 data byte. • 0 = Returns all active fault codes The returning packet contains a variable amount of data bytes. A two-byte value represents each error code. If a single fault is active, the data length will be 2 data bytes. If two faults are active, the data length is 4 data bytes, and so on. If no faults are active, the data length is 0. If a CSR is returned, the data length is 1.	1	Variable
211 **FPGA software revision**	Requests the revision of the FPGA software. Returns 4 ASCII characters.	0	4

Table 4-17. *AE Bus Commands (Continued)*

Command	Description	Number of Transmit Data Bytes	CSR Codes or Number of Response Bytes
220 **request customer service statistics**	Requests unit statistics; returning packet contains 4 data bytes (32-bit value). Send 1 data byte (8-bit value): • 0 = Total output in kilowatt-hours • 1 = Total idle time • 2 = Total run time • 3 = Total unit on events • 4 = Total output on events • 5 = Total over-temperature events • 6 = Total control circuit faults • 7 = Total out-of-set point events • 8 = Total hard bus fault events • 9 = Total power fluctuation events • 10 = Unassigned • 11 = Total Side A inverter low events • 12 = Total Side B inverter low events • 13 = Total user interlock open events • 14 = Total cable interlock open events • 15 = Total contactor interlock open events • 18 = Total PROFIBUS fault events • 19 = Total pre-defined interrupt events • 20 = Total unassigned interrupt events • 22 = Total dsp watchdog faults • 24 = 10 ms bus fault events	1	4 (May return CSR code 5)
223 **request unit's fault status**	AE service request	0	4

Table 4-17. *AE Bus Commands (Continued)*

Command	Description	Number of Transmit Data Bytes	CSR Codes or Number of Response Bytes
230 **request logic, panel, or DSP CRC**	Requests the crc of the logic, front panel or DSP. The returning packet contains 2 data bytes (16-bit value). • To receive the logic CRC, first send command **24**, which calculates the value. With command **230**, send one data byte: • 0 = Logic • 2 = DSP	1	2 (May return CSR code 5)
232 **request near end joule setting**	Requests the near end joule setting, set with command **72**.	0	2
233 **request number of recipe repititions**	Request the number of recipe repetitions, set with command **59**. Returns 4 data bytes. • Bytes 1 and 2 = Number of repetitions set • Bytes 3 and 4 = Current repetition in process (reports 0 if output is off)	0	4
251 **special DeviceNet**	Requests the full-scale power for DeviceNet (32-bit value).	0	4
252 **special DeviceNet**	Requests the full-scale current for DeviceNet (32-bit value).	0	4
253 **special DeviceNet**	DeviceNet poll commands. The returning packet contains 8 data bytes.	0	8

FRONT PANEL ILLUSTRATIONS

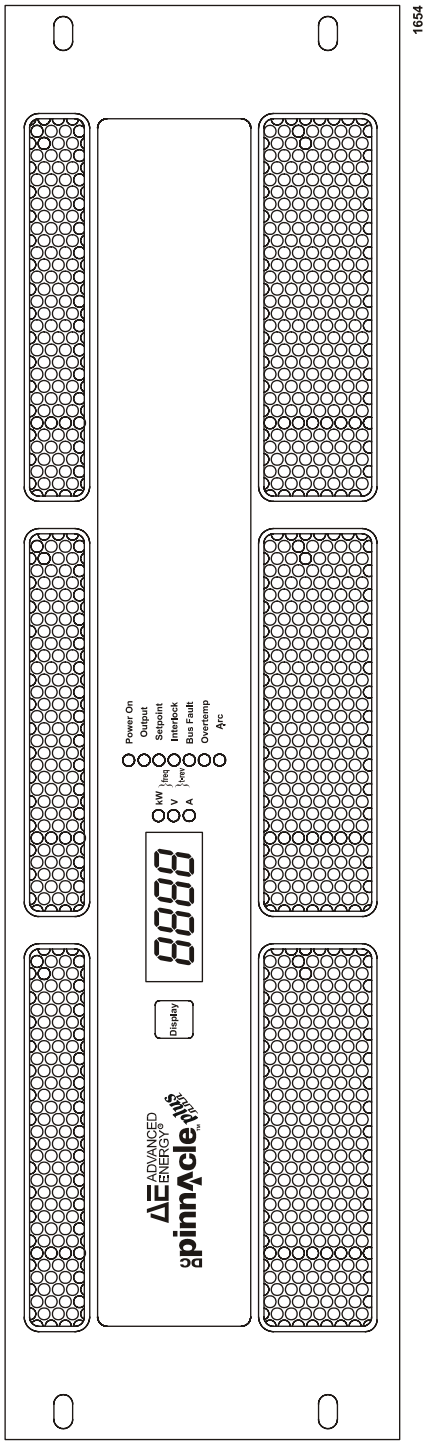

Figure 4-17. *Passive front panel (front view)*

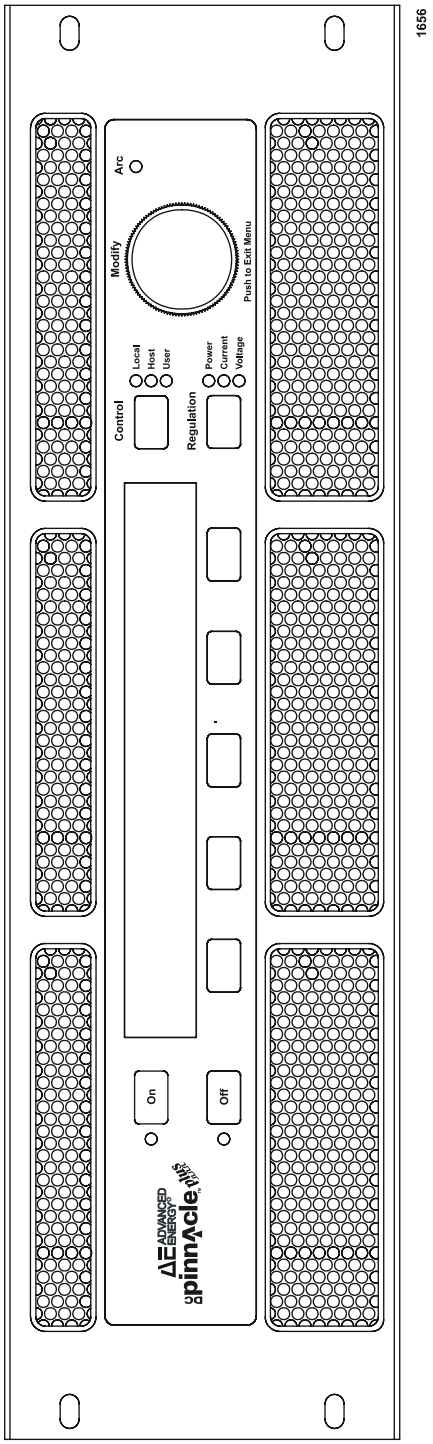

Figure 4-18. *Active front panel (front view)*

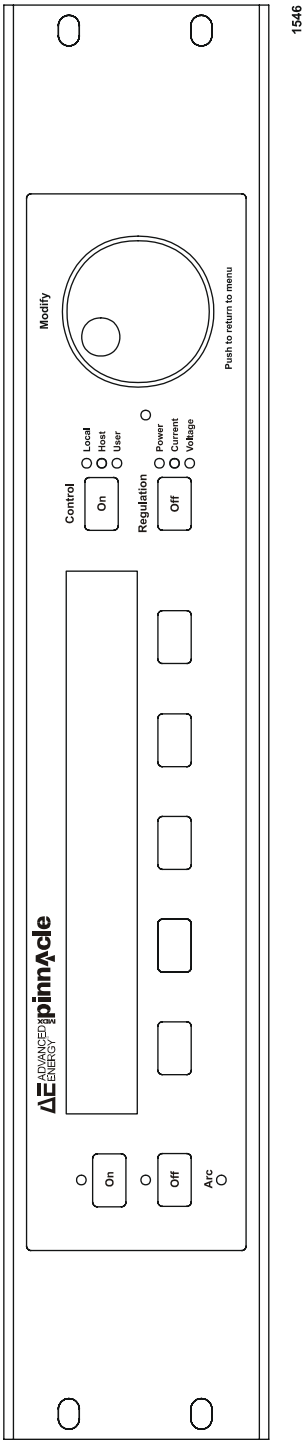

Figure 4-19. *Remote panel (front view)*

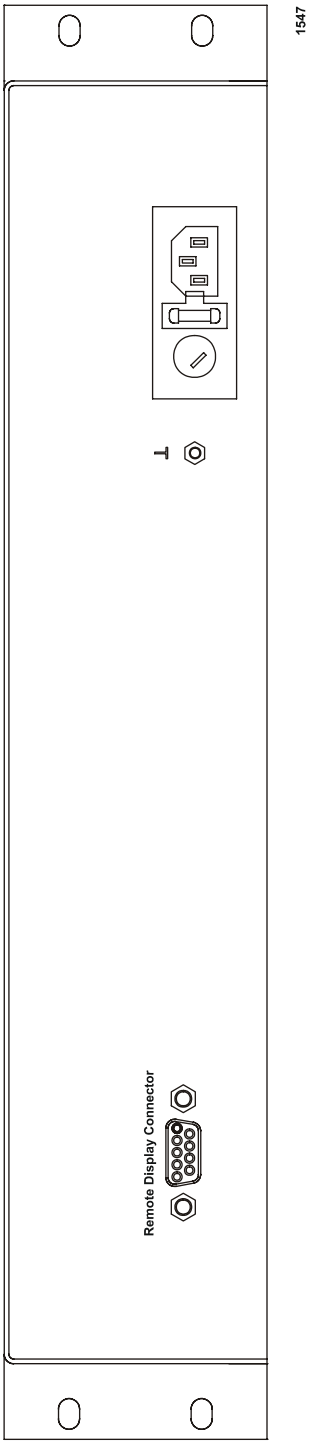

Figure 4-20. *Remote panel (rear view)*

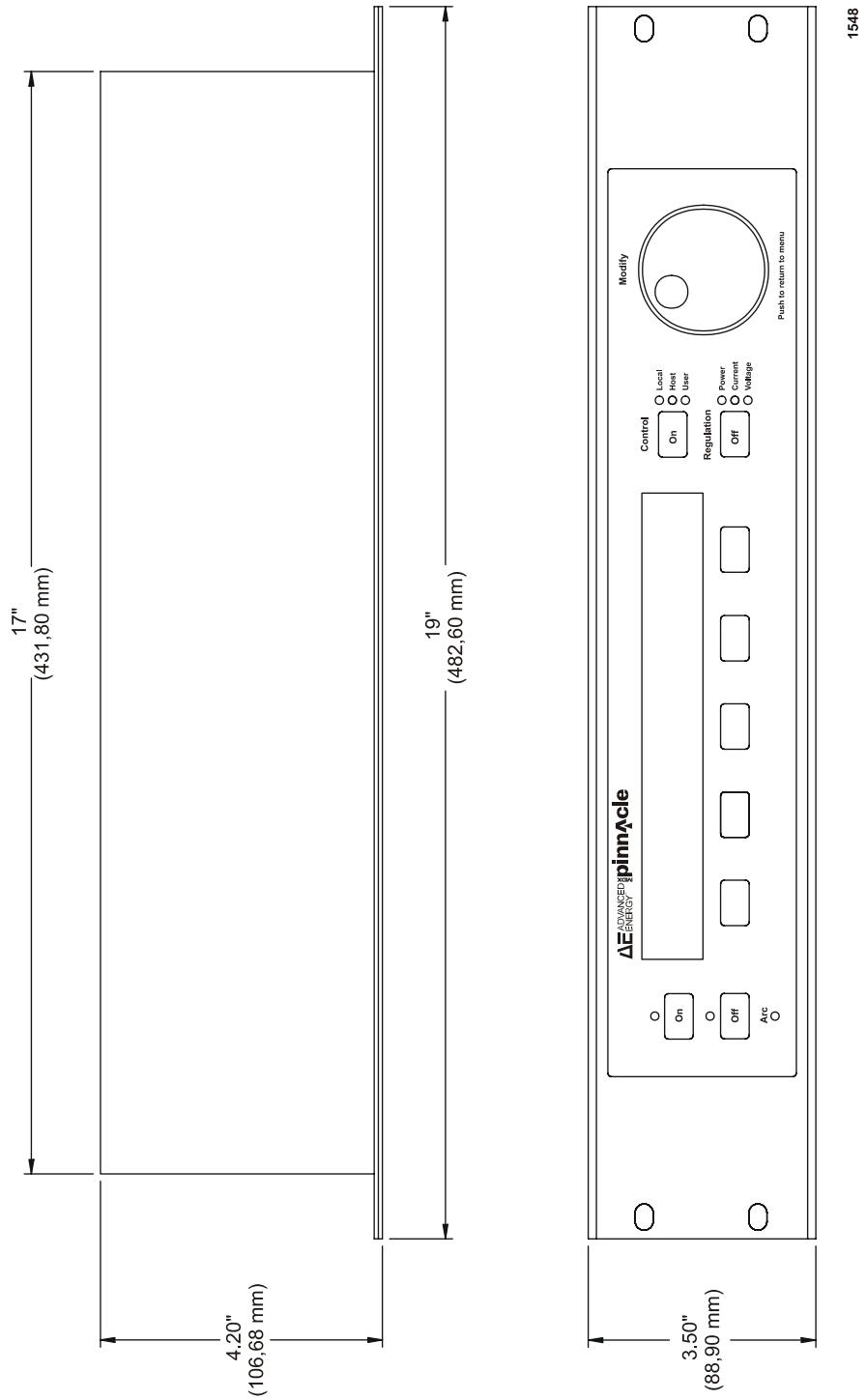

Figure 4-21. *Remote panel (dimensions)*

Installation

UNPACKING

Unpack and inspect your power supply carefully. Check for obvious physical damage. If no damage is apparent, proceed with the unit connections. If you do see signs of shipping damage, contact Advanced Energy Industries, Inc., and the carrier immediately. Save the shipping container for submitting necessary claims to the carrier.

MEETING SPACING REQUIREMENTS

See Figure 5-2 on page 5-3 for a graphical representation of the spacing requirements.

- The clearance between either side of the Pinnacle Plus+ supply and the enclosure must be 76 mm (3 in).
- The clearance between the top of the Pinnacle Plus+ supply and the top of the enclosure must be 25 mm (1 in).
- No clearance is required between power supplies.
- The clearance between the rear of the Pinnacle Plus+ supply and the enclosure must be 102 mm (4 in), with adequate ventilation.

Figure 5-1. *Dimensional drawing*

COOLING REQUIREMENTS

> **WARNING:**
> **For CE-marked power supplies: Install and operate this device only in a pollution degree 2 or better environment, which means an indoor location such as a computer room, office, or factory floor where only non-conductive pollution occurs during operation. Occasionally, condensation causes temporary conductivity when the device is not operating**.

For the Pinnacle Plus+ supply to be sufficiently cooled, the cabinet must be set up to:

- Bring in sufficient coolant air of the correct temperature (0 to 40ºC maximum)
- Distribute coolant air to the power supplies
- Prevent air exhausted from the cabinet from circulating back and becoming input air
- Exhaust the hot air from the cabinet with minimal airflow restriction

See Figure 5-2 on page 5-3 for a dimensional diagram.

Cabinet Design

The following is a synopsis of the principles to follow when designing a cabinet containing a stack of Pinnacle Plus+ power supplies.

Coolant air must be drawn easily into the cabinet; exhaust air must be able to pass unrestricted out of the cabinet. If some physical constraint restricts the flow of exhaust air out of the cabinet, we recommend that fans or blowers be mounted so that the hot air is removed from the cabinet as quickly as possible.

Each Pinnacle Plus+ kW supply dissipates up to 10% of its maximum power at full rated output. The minimum air flow required by the Pinnacle Plus+ kW supply is CFM (cubic feet per minute) The static pressure (inches of water) of the empty cabinet should not exceed 0.1 inches of water at the CFM level obtained by adding together the minimum CFM values for all the power supplies that will be placed in the cabinet.

For example, if three Pinnacle Plus+ kW units were to be mounted in a cabinet (see Figure 5-2 on page 5-3), the minimum CFM requirement would be CFM of cabinet air volume (CFM). This would result in a total power dissipation within the cabinet of W (W). The difference in temperature between coolant air and exhaust air would be approximately 20°C.

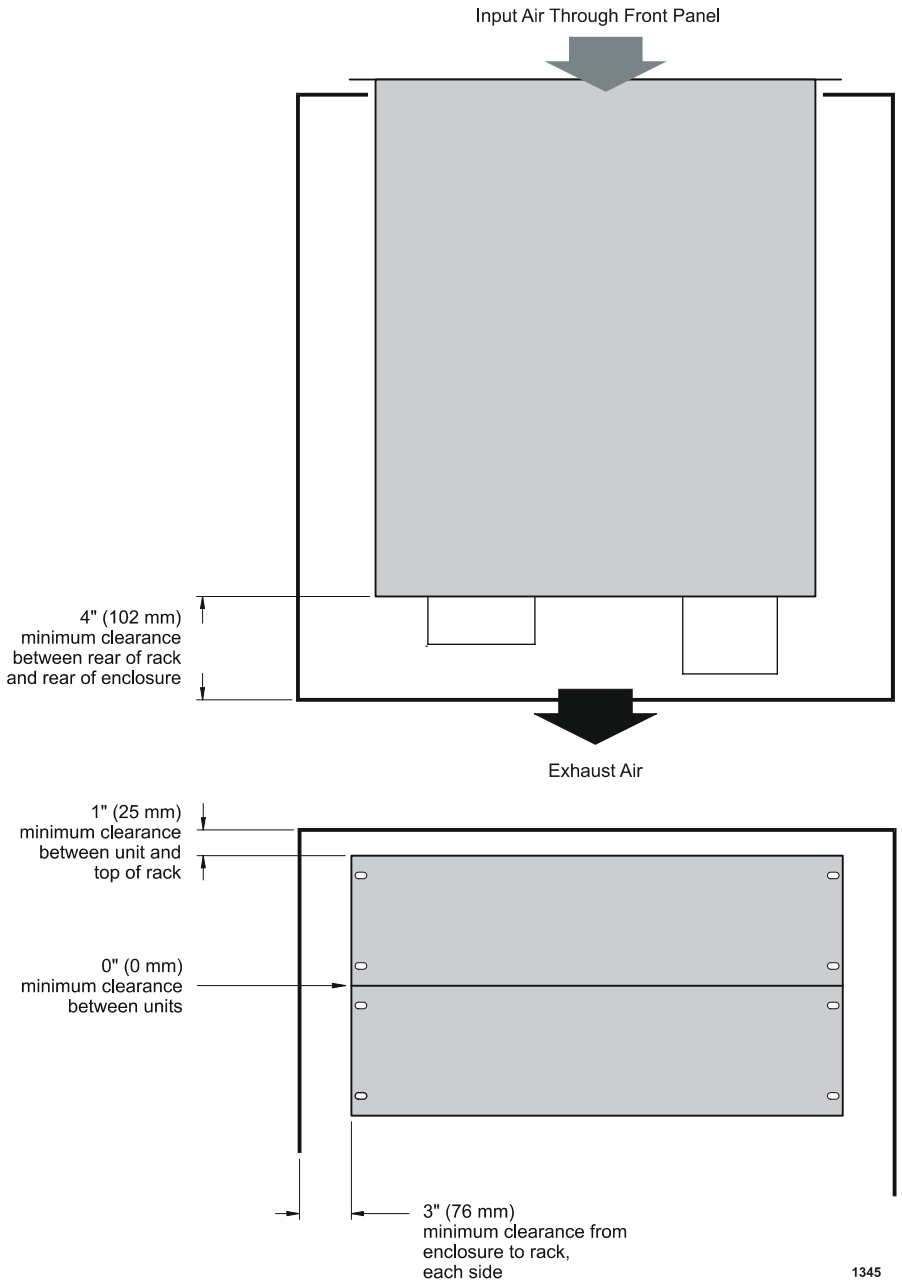

Figure 5-2. *Clearances for Pinnacle™ Plus+ units stacked in a cabinet*

MAKING REAR PANEL CONNECTIONS

WARNING:
RISK OF DEATH OR BODILY INJURY. Disconnect all sources of input power before working on this unit or anything connected to it.

CAUTION:
Do not apply RF power directly to the output of the Pinnacle Plus+ unit. Damage to the Pinnacle Plus+ unit could result. If you are using both an RF power supply and a Pinnacle Plus+ supply in the same system, include an RF filter in the system.

Grounding

For your convenience, the rear panel of the Pinnacle Plus+ kW supply features three equi-potential ground studs: two M5 studs and a 10-32 stud. These are indicated on the rear panel by a ground symbol.

Note: You must ground the power supply as specified by the conditions of use. See "Conditions of Use" on page 1-6 for more information.

CAUTION:
Before making any other connection, connect one of the equi-potential ground studs to earth ground.

Note: For optimal performance, ground an equi-potential ground stud to the system ground.

Connecting a Pinnacle Remote Active Panel

Connections for an Advanced Energy Pinnacle Remote Active Panel are made through a 9-pin, male, subminiature-D connector labeled REMOTE on the rear panel. See the "I/O Communication and Control" chapter.

Note: To reduce EMI interference, we recommend using shielded cable to connect to the Remote Active Panel port.

Connecting a Remote Passive Panel

Connections for a remote passive front panel are made through the female, 15-pin, subminiature-D connector labeled MONITOR on the rear panel. The rear of the remote passive panel features a male, 15-pin, subminiature-D connector. Use the cable provided with the remote passive panel to connect the panel to your Pinnacle Plus+ unit.

Connection for User Port Control

Please reference the “I/O Communication and Control” chapter for instructions on connecting your analog/digital interface.

Note: To reduce EMI interference, we recommend using shielded cable to connect to the User port.

Note: Grounding the User port at the power supply reduces noise interference. To avoid ground loop problems, you should typically ground only one end.

Connecting to the Standard Serial Port

This interface lets you use most parameters of the AE Bus communications protocol during serial communications with a host computer. Please reference the “I/O Communication and Control” chapter for details on making this connection.

Note: To reduce EMI interference, we recommend using shielded cable to connect to the serial port.

Connection for Serial (Host) Port Control

Please reference the “I/O Communication and Control” chapter for instructions on connecting your serial communications (Host) port.

Note: Any time you remove one Host card and replace it with another, you must restore all system defaults. Restoring defaults will reset User limits and ensure the Pinnacle Plus+ unit recognizes the new Host card.

Note: To reduce EMI interference, we recommend using shielded cable to connect to the Host port.

Contactor Interlock

WARNING:
The Contactor interlock is *not* a safety interlock.

The CONTACTOR INTLK port, located on the rear panel, is a 9-pin, male, subminiature-D connector (see Figure 5-3 on page 5-6). Before turning on output, ensure that the interlock loop is closed.

Note: Avoid injection of RF or noise from any power cables.

To enable the Pinnacle Plus+ supply's main contactor short together pins 3 and 4 on the CONTACTOR INTLK port (through a cheater plug, external switch, or relay).

Pin 4 supplies the interlock system (string) with 18 V, and it can source 60 mA. Pin 3 can sink 60 mA, and the voltage on pin 3 and pin 4 should not exceed 20 V. Pins 1 and 2 on this port are feedback connections from a set of (normally closed) auxiliary connectors on the main contactor.

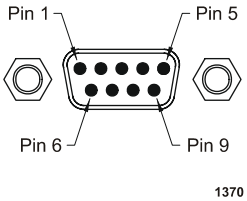

Figure 5-3. *Contactor interlock connector*

Note: The mating connector, connector shell, and post screws are included in the hardware kit that accompanied your Pinnacle Plus+ unit.

Connecting Input Power

All power supplies leave the factory with their input voltages identified on the rear panel and on an enclosed test checklist. The Apex generator power supply provides the following input voltages (depending on your unit configuration):

- 208 VAC (wye or delta connection)
- 230/400 VAC (wye connection only)
- 277/480 VAC (wye connection only).

All input voltages are three-phase, 50/60 Hz.

The AC line input connection is provided by means of a five terminal, DIN terminal block on the rear panel. Labels on the input terminal shield and below each terminal position on the rear panel show line (L3, L2, L1), neutral (N), and Protective Earth (ground) connections.

Note: No neutral connection is required. However, if neutral is present, connect it to the N terminal.

DANGER:

This device must be operated in an overvoltage II category installation only.

To connect your system to the power supply, you need stranded wire of a gauge consistent with your application and applicable requirements and the power input specification.

To connect to the power supply's input power connector:

1. Strip approximately 60 to 70 mm of the insulation from the end of the power cord.
2. Separate the five wires and strip approximately 10 mm of the insulation from each wire.
3. Ensure that the ground wire (the yellow and green wire) is approximately 7 mm longer than the other wires.
4. Crimp on each lead a ferule of appropriate size.
5. Remove strain relief housing.
6. Slip the cable through the strain relief.
7. Connect each wire to the proper input terminal block according to the labels. Replace the housing. Tighten strain relief.

Connecting Output Power

DANGER:

RISK OF DEATH OR BODILY INJURY. Disconnect all sources of input power before working on this unit or anything connected to it.

WARNING:
Operating and maintenance personnel must receive proper training before installing, troubleshooting, or maintaining high-energy electrical equipment. Potentially lethal voltages could cause death, serious personal injury, or damage to the equipment. Ensure that all appropriate safety precautions are taken.

WARNING:
To meet EMI /EMC requirements the shield of the output cable must be connected to the shell of the UHF connector, or the shell of the two-terminal connector.

A triax cable will allow a floating output of the power supply, but the center connector has to carry the high voltage to ground potential. No terminal should exceed 1700 V to ground (peak).

CAUTION:
Improper connection to the output connector could hamper operation of the Pinnacle Plus+ unit. If you are unsure how to connect your output cable between the Pinnacle Plus+ unit and your chamber, please contact AE Customer Support.

OUTPUT POWER CABLE RECOMMENDATIONS

Choosing the appropriate output power cable for your Pinnacle Plus+ supply will produce the best process results. For UHF connectors, RG393 cable is recommended. For two-pin pluggable connectors, twisted pair cable with an external shield is recommended, or RG393 for use with PG-11 style strain relief connectors.

In general, the shortest cable will give you the widest process window and the best results; cables should be no longer than 3.05 m (10 ´). Long cables may cause the Pinnacle Plus+ supply to turn off because of excessive reflected power.

WARNING:
Never use an output power cable longer than 9.15 m (30 ´) or damage to your Pinnacle Plus+ unit may result.

Master/Slave Operation

Note: This function is *only* available on units specially configured for master/slave operation at the factory and equipped with a master/slave Host card.

Up to six Pinnacle Plus+ power supplies may be configured to operate in a master/slave system, allowing you to increase your total system power up to 60 kW. Any Pinnacle Plus+ unit that features the master/slave Host card can function as either a master unit or a slave unit. (See Figure 5-4 on page 5-9 for an illustration of the master/slave Host card.)

Note: Pinnacle Plus+ units without a master/slave Host card cannot function as a master or slave.

Note: When running a master/slave system in voltage regulation, be aware that the Pinnacle Plus+ units may not share current or power.

Host Port Card (Master/Slave Operation)

The master/slave card is located near the top left side of the unit's rear panel (when facing the rear panel). The master/slave Host card includes three ports: a 9-pin, female, subminiature-D serial communications port for external serial control, and two modular ports (P1 and P2) for connecting master and slave units with the master/slave cable (see Figure 5-4 on page 5-9).

Note: See “Host Port Connector” in Chapter 4 for pin and signal descriptions for the 9-pin Host port connector.

The P1 and P2 molded-plug ports are used to connect (daisy-chain) a master unit to a slave unit and a slave unit to another slave unit.

Note: The Master/Slave Pulse port must also be connected between master and slave units.

The Host card also includes a master/slave (MSTR/SLV) switch. This switch is used to indicate whether the supply is functioning as a master, stand-alone, or slave unit.

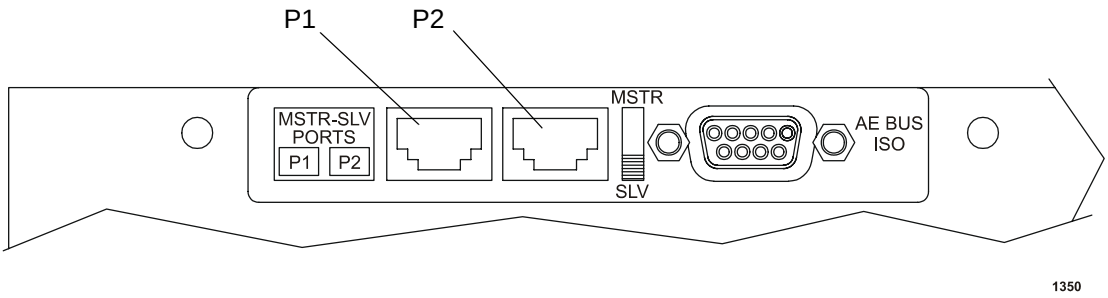

Figure 5-4. *Pinnacle Plus+ master/slave interface Host card*

Master/Slave Pulse Port

The Pinnacle Plus+ unit is configured with two female, subminiature-D ports beneath the master/slave Host card on the rear panel of the unit.

The 15-pin subminiature-D port, labeled Master/Slave Pulse, is used for master/slave operations. The 9-pin subminiature-D port, labeled Sync Pulse, is used for synchronized pulsing operations and is discussed later in this chapter. (See “Sync Pulse Operation” on page 5-15.)

Note: See the rear panel illustration of the Pinnacle Plus+ power supply at the end of this chapter for the location of these ports.

MASTER/SLAVE PULSE PORT CONNECTOR

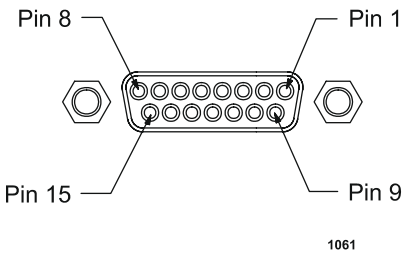

Figure 5-5. *Master/Slave Pulse port connector*

MASTER/SLAVE PULSE PORT PIN DESCRIPTIONS

The following table provides pin and signal descriptions for the Master/Slave Pulse port.

Table 5-1. Master/Slave Pulse Port Pin and Signal Descriptions

Pin	Associated Pin	Pin Name	Description
1	n/a	unassigned	unassigned
2	n/a	unassigned	unassigned
3	n/a	unassigned	unassigned
4	5	*POFF-MSP*	Pulse Off signal
5	4	*POFF-MSP Return*	Pulse Off signal return
6	7	*PON-MSP*	Pulse On signal

Table 5-1. Master/Slave Pulse Port Pin and Signal Descriptions

Pin	Associated Pin	Pin Name	Description
7	6	*PON-MSP Return*	Pulse On signal return
8	Cable shield	*SYNC_POWER_SENSE*	Verifies all units have logic control power
9	n/a	unassigned	unassigned
10	n/a	unassigned	unassigned
11	12	*OC-MSP*	Overcurrent signal
12	11	*OC-MSP Return*	Overcurrent signal return
13	14	*OV-MSP*	Overvoltage signal
14	13	*OV-MSP return*	Overvoltage signal return
15	n/a	unassigned	unassigned

MASTER/SLAVE PULSE PORT CABLE

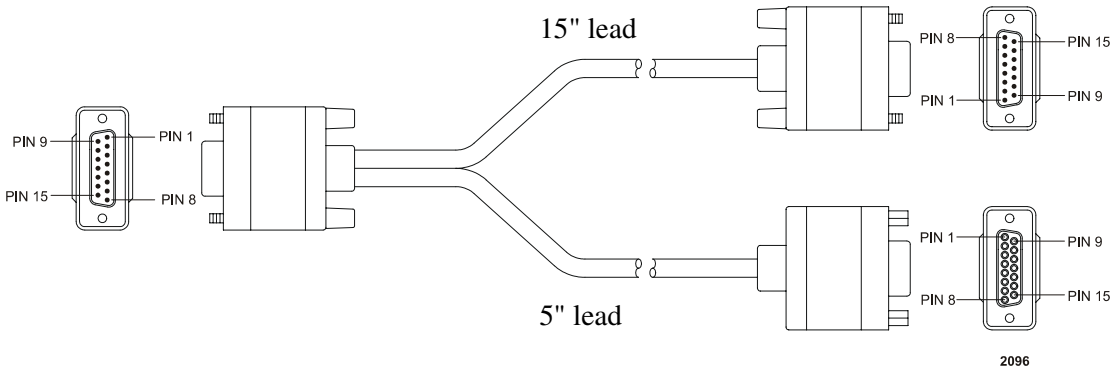

Figure 5-6. *Master/Slave Pulse port cable*

Configuring Your Master Unit

Note: See Figure 5-7 on page 5-13 for an illustration.

To configure the master unit:

1. Remove all input power from the master and slave units.

2. If the Pinnacle Plus+ supply includes a User card, ensure that the interlock inputs are satisfied. Refer to the “I/O Communication and Control” chapter for specific User port pin descriptions and required voltage levels.
3. Set the MSTR/SLV switch (see Figure 5-4) in the "up" (MSTR) position.
4. Connect the included master/slave interface cable (with the modular plug ends) between port P1 (the MSTR port) on the master unit and port P2 (the SLV port) on the first slave unit.

   Note: The master unit will not have an interface cable connected to port P2.

5. Connect the included master/slave pulse interface cable (with the 15-pin, subminiature-D plug ends) between the port labeled (Master/Slave Pulse) on the master unit and the port labeled (Master/Slave Pulse) on all associated slave units.
6. Use a grounding strap to connect an equi-potential ground stud on the master unit to an equi-potential ground stud on the first slave unit.

To configure a master unit as a stand-alone unit, do the following:

1. Set the MSTR/SLV switch in the "up" (MSTR) position.
2. Remove all Master/Slave interface cables from the master unit.

Configuring Your Slave Units

To configure a slave unit:

Note: See Figure 5-7 on page 5-13 for an illustration.

1. Remove input power from the master and slave units.
2. If the Pinnacle Plus+ supply includes a User card, ensure that the interlock inputs are satisfied. Refer to the “I/O Communication and Control” chapter for specific User port pin descriptions and required voltage levels.
3. Set the MSTR/SLV switch (see Figure 5-4) in the "down" (SLV) position.
4. Connect the included master/slave interface cable (with the modular plug ends) between port P1 on the first slave unit and port P2 on the next slave unit. Continue cabling slave units together in this daisy-chain manner.

   Note: The last slave unit on your system will not have an interface cable connected to port P1.

5. Connect the included master/slave pulse interface cable (with the 15-pin, subminiature-D plug ends) between the port labeled (Master/Slave Pulse) on the master unit and the port labeled (Master/Slave Pulse) on all associated slave units.
6. Use a grounding strap to connect an equi-potential ground stud on the first slave unit to an equi-potential ground stud of the next slave unit. Continue connecting together subsequent slave unit chassis in this manner. We recommend you connect the ground stud on the master unit to system ground.

MASTER/SLAVE CONFIGURATION EXAMPLES

The following block diagram provides a high-level view of possible configurations for a Pinnacle Plus+ master/slave system.

Note: See "Sync Pulse Configuration Examples" on page 5-17 for further possible configurations for master/slave operations.

Master/Slave Pulse System

The following configuration allows you to configure up to 6 Pinnacle Plus+ power supplies in a master/slave configuration. In this configuration the errors are shared among the network units.

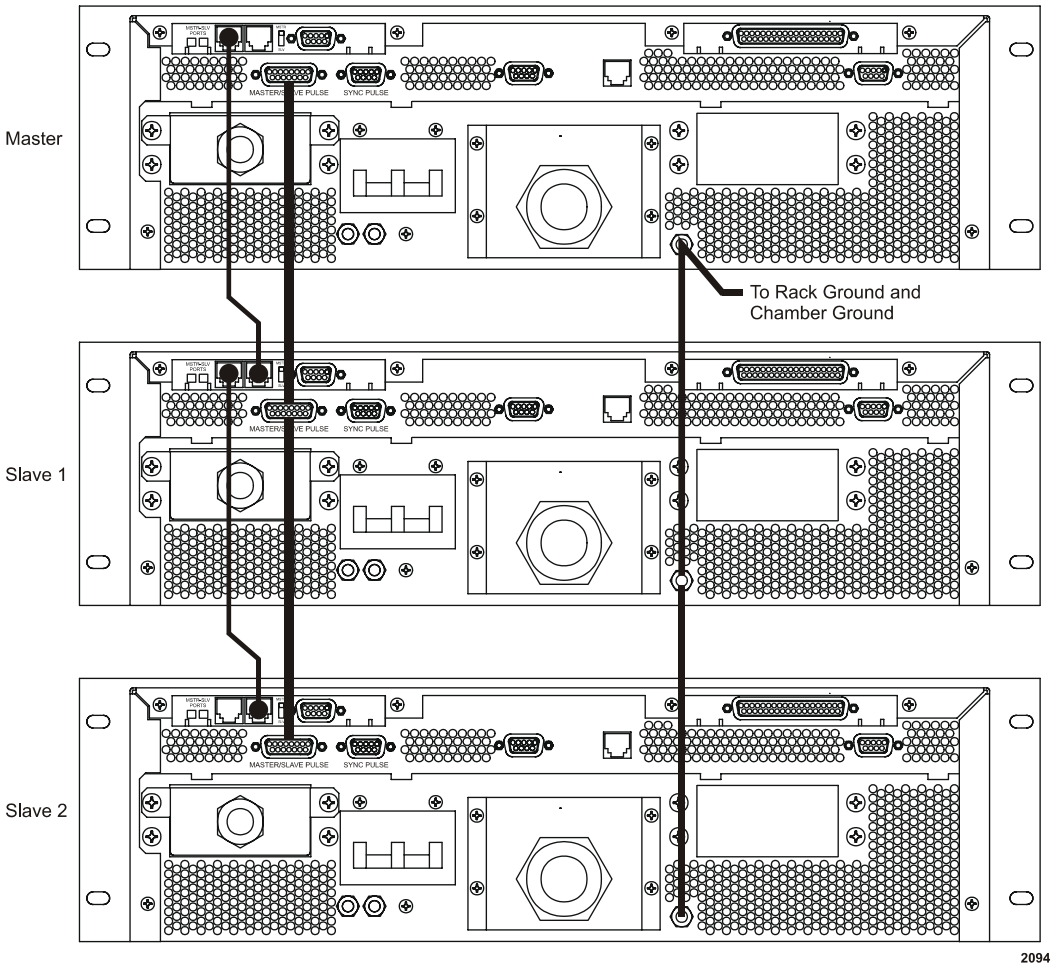

Figure 5-7. *Master/Slave Pulse system diagram*

Monitoring Your Master/Slave System

There are three options for monitoring your Pinnacle Plus+ units while in a master/slave configuration, depending on your unit's features. These options are as follows:

- If you have a passive front panel or remote passive panel attached to your master unit, you can view the combined output of your master/slave system (power or current). The passive front panel of each slave unit displays the individual unit's output. For more information, see the "I/O Communication and Control" chapter.
- If you have an active front panel or Pinnacle Plus+ Remote Active Panel attached to your master unit, you can monitor the output (power, current, or voltage) of your system and the output of each individual unit. For more information, see the "I/O Communication and Control" chapter.
- If you have a host computer connected to a serial port on your master unit, you can monitor the output (power, current, or voltage) of your system and the output of each individual unit.

CLEARING FAULTS IN A MASTER/SLAVE SYSTEM

If a slave unit experiences a self-clearing fault, both the master and slave units display an error code and the master unit shuts off output from all attached power supplies. When the fault condition clears, the master and slave units reset. You may then turn on output.

If a slave unit experiences an explicit clear fault, both the master and slave units display an error code and the master unit shuts off output from all attached power supplies. When the fault condition clears, you must acknowledge the condition at the master unit before turning on output. (For example, you must press the OFF button to acknowledge the condition and then the ON button to turn on output.)

The following table describes some of the errors you might encounter with a Pinnacle Plus+ master/slave system.

Table 5-2. Errors Associated With The Pinnacle Plus+ Master/Slave System

Condition	Possible Cause(s)
Master reports: "Master Slave Fault Detected."	• The master/slave cable has been removed. • The master/slave pulse cable has been removed. • The master/slave cables or switches set incorrectly.
Slave reports: "No Master/Slave Transmitter Detected"	• The master/slave pulse cable has been removed.
Any unit reports: "System Input Power Fault"	• One of the units in the system is not energized (that is, does *not* have input power).

Note: For more information about error codes, please refer to the "Troubleshooting" chapter.

MASTER/SLAVE INPUT ON/OFF COMBINATIONS

Unique logic in the Pinnacle Plus+ power supply lets you power on and off master and slave units independently of one another. During on and off sequences, the master unit "re-scales" the total output; that is, its I/O signals adjust to accommodate the most recent change in output capability of the combined units.

SYNC PULSE OPERATION

Note: This function is *only* available on units specially configured for Sync Pulse operation at the factory.

A unique feature of the Pinnacle Plus+ power supply is that up to six units can be synchronized to operate at the same frequency with independent set points and On/Off control. This Sync Pulse feature is very useful for reducing arcing in multiple cathode applications. Additionally, Sync Pulse features a broadcast mode in which hard arc detection signals are transmitted to other units. The units receiving the hard arc signal will control its output in sync with all other units receiving the signal.

Note: The Sync Pulse feature may be available even if your unit is not configured with a master/slave Host card.

The broadcast hard arc detection feature can be disabled from the Active Front Panel, or from a Remote Active Front Panel by using the Process menu.

To Enable/Disable Broadcast Hard Arc Detection:

- Press SUPPLY → PULSE→ B'CAST

Sync Pulse Port Connector

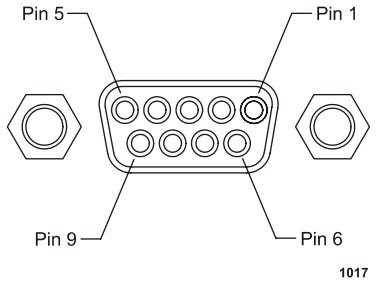

Figure 5-8. *Sync Pulse connector*

Sync Pulse Port Pin Descriptions

The following table provides pin and signal descriptions for the Sync Pulse port.

Table 5-3. Sync Pulse Port Pin and Signal Descriptions

Pin	Associated Pin	Pin Name	Description
1	6	*SYNC_POWER_SENSE*	Verifies all units have logic control power
2	6	*+8V*	+8V for future distribution box
3	7	*HARC-SP*	Hard Arc
4	8	*PON-SP*	Pulse On
5	9	*POFF-SP*	Pulse Off
6	1 and 2	*GND*	Ground (chassis)
7	3	*HARC return*	Hard Arc signal return
8	4	*PON-SP return*	Pulse On signal return
9	5	*POFF-SP return*	Pulse Off signal return

Sync Pulse Port Cable

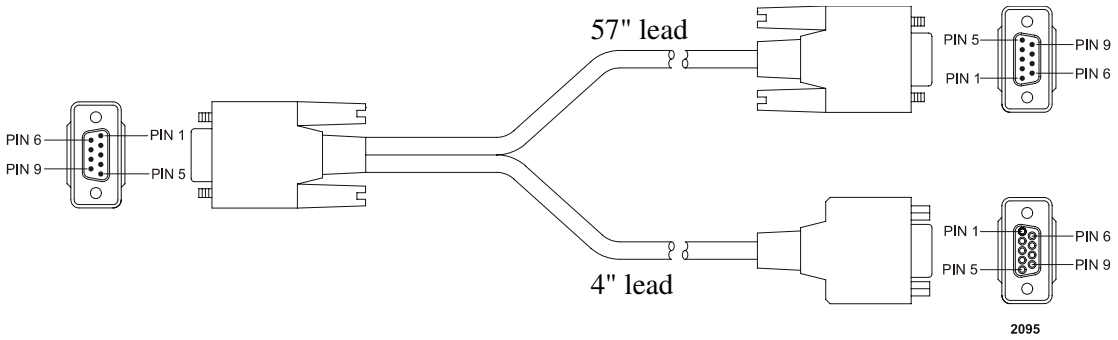

Figure 5-9. *Sync Pulse cable*

CONFIGURING FOR SYNC PULSE TRANSMIT/RECEIVE

To configure the unit to transmit or receive:

1. Remove all input power from the transmit and receive units.
2. Using the soft keys on the Active Front Panel or Remote Active Front Panel, select: SUPPLY → PULSE → TX/RX.
3. Set the unit to TRANSMITTER or RECEIVER.

   Note: One unit must be set to transmit; all other units must be set to receive.

4. Repeat steps 1 and 2 for the rest of the units.

   Note: Units can not be hot-plugged for Sync Pulse to operate.

Sync Pulse Configuration Examples

The following block diagrams provide a high-level view of possible configurations for a Sync Pulse system.

SIMPLE SYNC PULSE SYSTEM

The following configuration allows you to broadcast hard arcs or not broadcast hard arcs. In this configuration hard arcs are the only detection shared between the network units.

In the Sync Pulse system all units pulse at the same frequency but may have their own unique output power set point. Additionally, all units must have the same duty cycle and reverse time.

Note: If different duty cycles and reverse times are desired for your process, operate the Pinnacle Plus+ units as independent units.

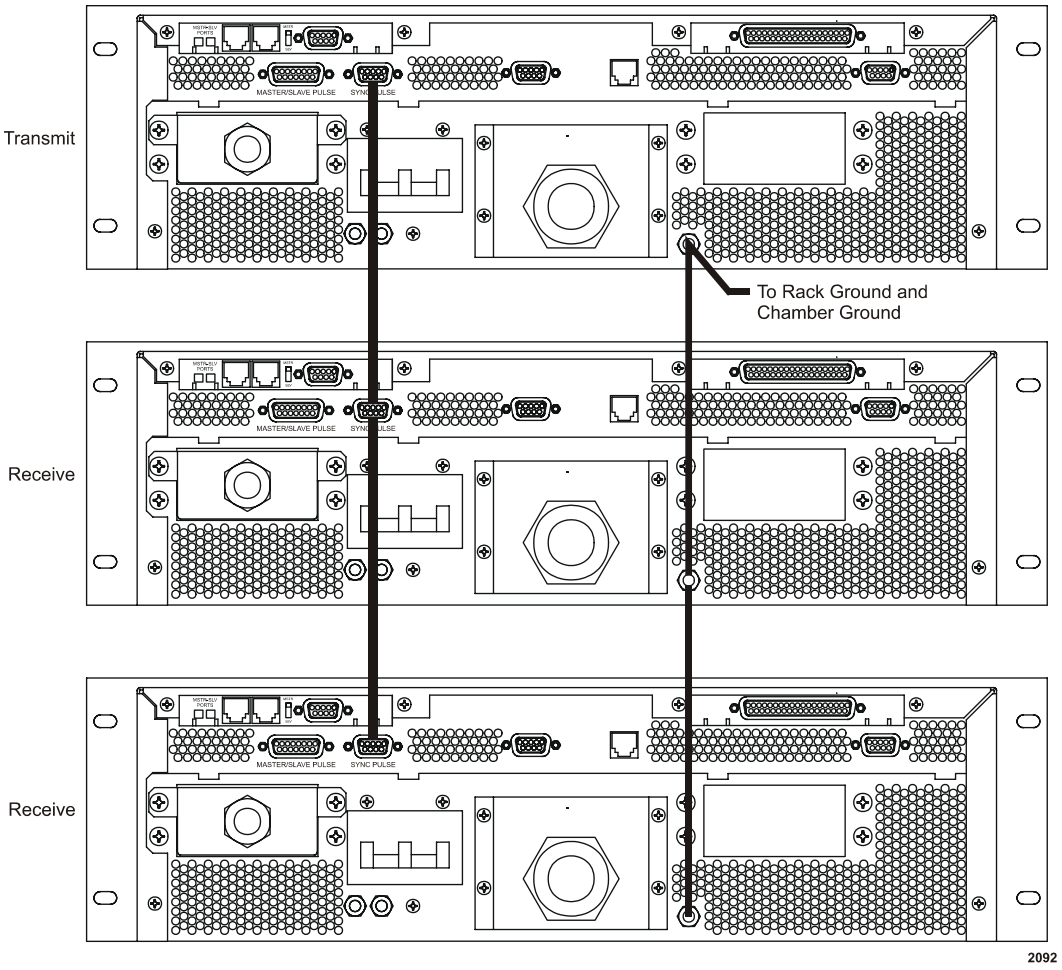

Figure 5-10. *Simple Sync Pulse system*

SYNC PULSE MASTER/SLAVE SYSTEM

You can place a series of master/slave Pinnacle Plus+ systems together in a sync pulse system, allowing for extraordinary control over hard arcs across a large network of power supplies.

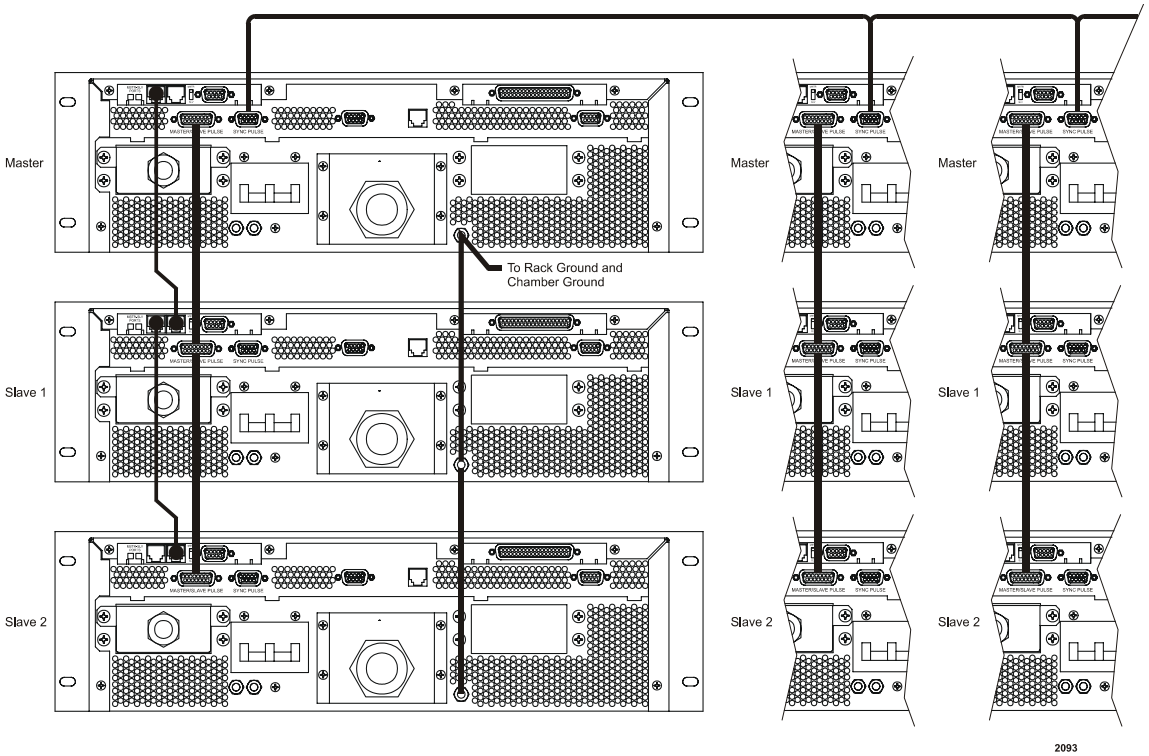

Figure 5-11. *Sync Pulse master/slave configuration*

MONITORING YOUR SYNC PULSE SYSTEM

There are three options for monitoring your Pinnacle Plus+ units while in a sync pulse configuration, depending on your unit's features. These options are as follows:

- If you have a passive front panel or remote passive panel attached to any unit in the system, you can view the out for that unit. For more information, see the "I/O Communication and Control" chapter.
- If you have an active front panel or Pinnacle Plus+ Remote Active Panel attached to any unit in the system, you can monitor the output (power, current, or voltage) of the unit and its set points. For more information, see the "I/O Communication and Control" chapter.
- If you have a host computer connected to a serial port on any unit in the system, you can monitor the output (power, current, or voltage) of the unit and its set points.

Clearing Faults in a Sync Pulse System

The following table describes some of the errors you might encounter with a Pinnacle Plus+ master/slave system.

Table 5-4. Errors Associated With The Pinnacle Plus+ Sync Pulse System

Condition	Possible Cause(s)
Transmit unit reports: "Multiple Sync Pulse Transmitters Detected"	• Two or more units have been designated as transmitters. *Note:* Multiple transmitter errors are detected only at power up or when changing port directions.
Receive unit reports: "No Sync Pulse Transmitter Detected"	• The sync pulse cable has been removed. • All units in the system are designated as receivers. *Note:* No transmitter errors are detected any time the unit is powered up.
Any unit reports: "System Input Power Fault"	• One of the units in the system is not energized (that is, does *not* have input power).

Note: For more information about error codes, please refer to the "Troubleshooting" chapter.

REAR PANEL ILLUSTRATION

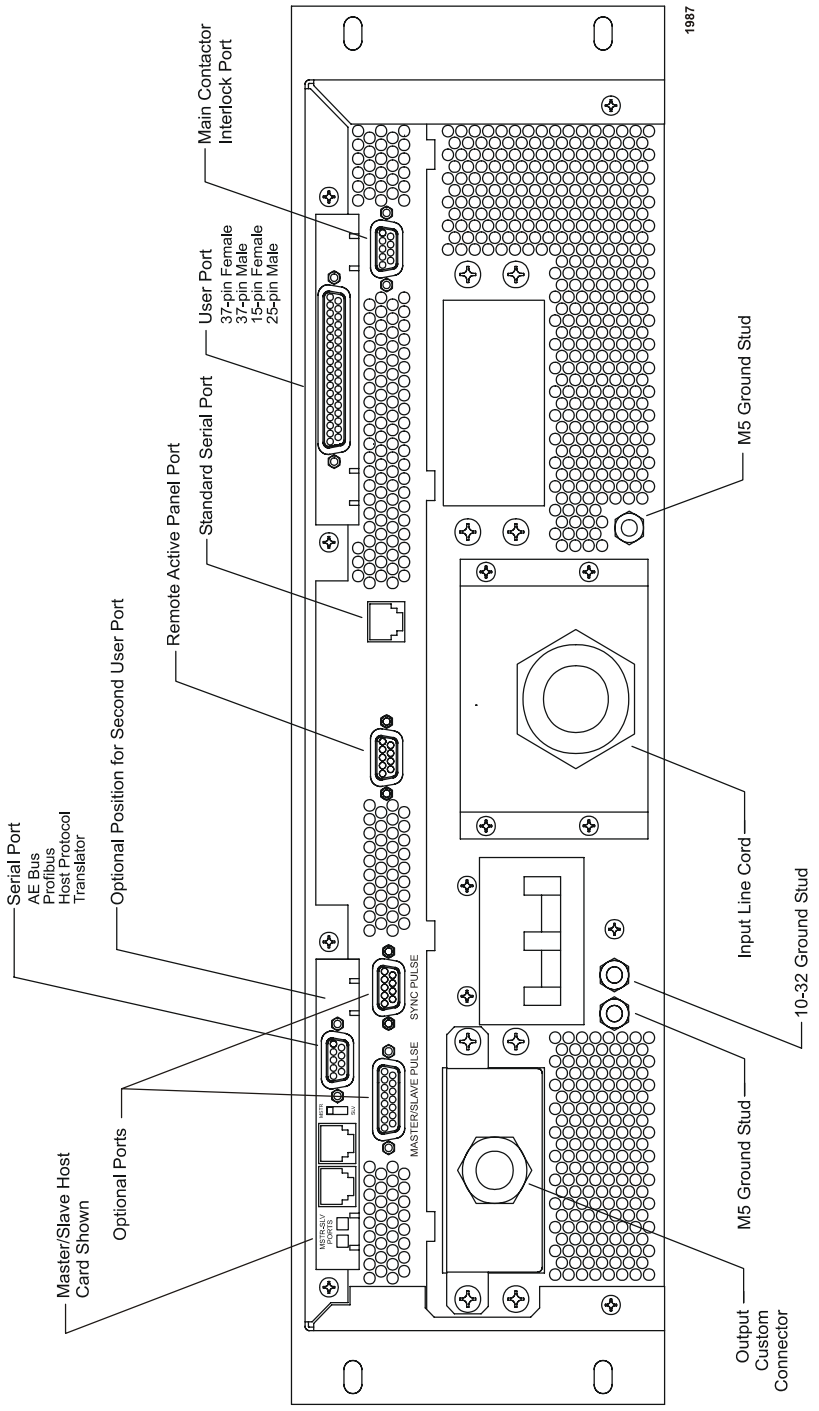

Figure 5-12. *Rear view illustration*

Operation

OPERATING OVERVIEW

The following list represents a general description of how to operate a Pinnacle Plus+ unit. You will want to adapt this list to your Pinnacle Plus+ configuration and your application, environment, and requirements.

1. Power on the Pinnacle Plus+ unit.
2. If you are using a passive panel, verify that the POWER ON and INTERLOCK LEDs light. If the INTERLOCK LED does not light, an error code should appear (see the “Troubleshooting” chapter for more information).

   If you are using an active front panel or a Pinnacle Remote Active Panel, verify that the display screen displays “Advanced Energy, Fort Collins, Colorado.” In addition, verify that an LED lights to show the control setting and another lights to show the regulation setting. Finally, verify that the OFF LED lights.

   Note: If an error code (that is, an “EXXX” code) appears scrolling on the front panel or on the Pinnacle Remote Active Panel, refer to the “Error Code Troubleshooting Table” in the Troubleshooting chapter (Chapter 7)for an explanation and troubleshooting suggestions.

3. If you are using the passive panel, verify that the BUS FAULT and OVERTEMP LEDs are not lighted. If either or both is lighted, power down the Pinnacle Plus+ unit, clear the fault, and return to Step 1. (Refer to the “Troubleshooting” chapter for error code explanations and troubleshooting suggestions.)

   If you are using an active front panel or the Pinnacle Remote Active Panel, verify that the two-line display information shows on the display screen (see the “I/O Communication and Control” chapter for details). If the display screen shows an error code and message, note the error code number and refer to the “Troubleshooting” chapter.

4. Select a method of control: Host (serial) port, User port, or local (panel control).
5. Select a regulation mode: power, current, or voltage.

   Note: Output power must be off (that is, output must be de-energized) to switch between regulation modes.

6. Enter a set point value.
7. If necessary, enter a pulse frequency and reverse time.
8. If necessary, enable joule mode and select a set point in joules.

9. If necessary, enable target life counters and select a target life for each applicable target.
10. If necessary, enable arc handling and enter appropriate arc-handling parameters.
11. If necessary, create a ramping recipe (available through the standard serial port, Profibus, or Pinnacle Remote Active Panel).
12. If necessary, set the out-of-set point timer to a value other than 0.
13. If necessary, set limits for output power, output voltage, output current, and/or process voltage.
14. Verify all output power load conditions and connections and, when the system is ready, enable the output. The output information on the output display screen should equal your requested set point.
15. If you are using a passive front panel, verify that the OUTPUT and SETPOINT LEDs light. If these LEDs do not light, see the “Troubleshooting” chapter for more information.

    If you are using an active front panel or the Pinnacle Remote Active Panel, verify that the ON LED lights. Also, verify that the display screen shows values for output information. If the display screen shows an error code and message, see the “Troubleshooting” chapter for error code explanations and troubleshooting suggestions.

UNDERSTANDING PINNACLE PLUS+ ARC HANDLING

Your Pinnacle Plus+ unit will power up every time with micro arc handling enabled. You can safely disable micro arc handling if your process allows it. Hard arc handling cannot be disabled.

The following paragraphs describe what the arc handling settings are and how they might interact with each other, with your system, and with your process.

Voltage Arc Trip Level

By setting the voltage arc (V-arc) trip level you are indicating the voltage threshold as measured at the DC inverter output (see Figure 2-1 on page 2-2) at which the Pinnacle Plus+ recognizes an arc. The best value for a voltage arc trip level is somewhere between your process's normal operating voltage and the typical low voltage that occurs when your system experiences a hard arc. The latter depends on your target

type, but typical low voltages for hard arcs are between 10 and 30 V. Thus a reasonable voltage arc trip level might be 50 V. Note, however, that some target types experience hard arcs at 100 V, so do not assume that 50 V is right for all processes.

Note: The recommeded V-arc trip level for low impedance metal targets is the default value of 70 V.

To set the V-arc trip level, use the ARC menu on an active front panel or the Pinnacle Remote Active Panel or AE Bus or PROFIBUS Command **10** (see the "I/O Communication and Control" chapter).

For sputter applications the V-arc trip level should be set above 60 V; for bias applications the V-arc trip level can be set below 40 V. A trip level between 40 V to 60 V can cause the unit to become unstable at start up.

FREQUENCY AND REVERSE TIME SETTINGS

Frequency and reverse time settings affect the arc and process behavior of the Pinnacle Plus+ supply.

AE defines reverse time as the time that the pulsing switch is closed, that is, when no power is transferred to the plasma. By action of the pulsing switch and output inductor, output voltage is reversed. (See Table 3-4 on page 3-7 for reverse time specifications.) Reverse time is only relevant during pulsing operation.

You need to adjust the ratio of sputter time and reverse time to optimize the rate and film properties for your process. To do so, you will need a good oscilloscope and a high voltage probe (2000 V rated) that has been calibrated for the scope you are using.

Note: AE recommends using a TEK 320, 380, 3054, 3012, 3032, or better, with a 1:100 P5100 voltage probe.

Frequency and reverse time settings can affect arc and process behavior in the following ways.

- Higher frequencies will reduce the tendency to arc.

  Note: Frequency is limited to 150 kHz when the pulse mode is set to be enabled always.

- Short reverse times will increase the rate, but may increase the number of micro arcs and possible hard arcs—especially if you are using a long output power cable.
- Frequency and reverse time define the maximum peak voltage at the cathode. Setting high frequencies and long reverse times will raise the plasma voltage during the sputter cycle. (Plasma voltage can be as much as double the DC voltage).

- Depending on the cable length and the cathode size, certain frequencies may cause resonance with the pulsing frequency. This resonance can cause the Pinnacle Plus+ supply to respond to a false arc or overcurrent event in excess. To avoid this problem, use a scope to make sure that the voltage does not ring back below the arc trip level after the cathode voltage is applied. Changing the frequency, output power cable length, and/or the reverse time settings can solve this problem.
- If you cannot reach a certain output power, increased reverse time will increase the output power at a given maximum DC output voltage shown at the front panel.

LOW POWER OPERATION VERSUS HIGH POWER OPERATION

The Advanced Capability Pinnacle Plus+ unit features two modes of operation which allow it to operate effectively in many processes and over a large range of power settings. To better manage these varied process requirements the Pinnacle Plus+ unit features two different modes of operation: low power (operation is 1000 W or less), and high power (power is greater than 1000 W).

To select the mode of operation one must set the user power limit based on the 1000 W dividing line. Because the unit cannot switch operation between the two modes while delivering power, selecting the power limit (and hence operation mode) is not allowed when the output is on.

The specific conditions under which the operation modes differ are:

- Initial output on or ignition
- Arc shutdown extinguishing the plasma
- Open load/ circuit condition at output

Additionally, the operational mode voltage limits are altered slightly should you select voltage as the mode of regulation.

Low Power Operation

For low power operation the power limit must be set to 1000 W or less, and the following is true:

Mode	Low Power Operation
Ignition	No ignition is present in all control modes. The Pinnacle Plus+ unit begins pulsing immediately.
Hard and Micro Arc Shutdown	Following the shutdown the unit continues to pulse regardless of plasma conditions.
Open Load/Circuit	The unit continues to pulse.

High Power Operation

For high power operation the power limit is set to greater than 1000 W, and the following is true:

Mode	High Power Operation
Ignition	Under high power operation (Power or Current regulation), pulsing is disabled, the voltage jumps to maximum voltage (~1350 V) and is held until the current is detected flowing above 0.5 A. At this time pulsing is started. Should 100 ms expire before pulsing begins, a duty cycle is imposed on the unit's voltage limit to prevent the unit from being damaged. This duty cycle is 100 ms at maximum voltage and 900 ms at the user voltage limit. This cycle will repeat until the current is detected flowing above 2.0 A at which time pulsing is started. *Note:* If the regulation mode is Voltage, the output on voltage will jump to a maximum of the set point plus 12.5% and no duty is imposed.
Hard Arc Shutdown	Following the shutdown should the unit detect the current has dropped below 0.5 A (which is a good indication the plasma has extinguished), the unit will return to ignition state, otherwise the unit continues to pulse.
Open Load/Circuit	Should the unit detect an open circuit condition, the unit will return to ignition state, otherwise, the unit continues to pulse.

CABLE RECOMMENDATIONS

Choosing the appropriate cable solution for your Pinnacle Plus+ supply will produce the best process results. For UHF connectors, RG393 cable is recommended. For two-pin pluggable connectors, twisted pair cable with an external shield is recommended, or RG393 for use with PG-11 style strain relief connectors.

In general, the shortest cable will give you the widest process window and the best results; cables should be no longer than 10 feet (3.05 m). Long cables may cause the Pinnacle Plus+ supply to turn off because of excessive reflected power.

⚠ WARNING:
Never use an output power cable longer than 9.15 m (30 ´) or damage to your Pinnacle Plus+ unit may result.

Troubleshooting and Global Customer Support

BEFORE CALLING AE GLOBAL CUSTOMER SUPPORT

DANGER:

RISK OF DEATH OR BODILY INJURY. Disconnect all sources of input power before working on this unit or anything connected to it.

The following pages contain two types of helpful troubleshooting sections:

- A general checklist of potential problem areas
- A list of error codes and suggested responses

Please consult the appropriate section(s) if you believe you are experiencing trouble with your Pinnacle Plus+ power supply. If the problem continues or if you cannot find an adequate solution in these pages, please call AE and ask to speak with a Global Customer Support representative.

WARNING:

Operating and maintenance personnel must have the correct training before setting up, maintaining, or troubleshooting high-energy electrical equipment. Potentially lethal voltages may cause serious personal injury or damage to equipment. Ensure that proper safety precautions are taken.

First Check

If you believe you are experiencing problems with a Pinnacle Plus+ supply, check for obvious signs of damage to the unit itself, cables, and connectors. If damage has occurred, power off the unit and call AE Global Customer Support. If there are no obvious signs of damage, proceed with the checks on the following lists.

Checks with the Unit Powered Off

Perform the following checks with the unit powered off.

1. Ensure the power to the unit is off
2. Check for visible damage to the unit, cables, and connectors.
3. Ensure all unit connectors are installed correctly and are fastened tightly.
4. Check to determine whether any system-related circuit breakers have been tripped.
5. Ensure all phases of the main input power are applied to the appropriate power supply terminals.
6. Ensure there is input power to both the unit and the remote, and ensure the input power meets specifications.
7. Ensure ground connections are adequate and secure and comply with local safety codes.
8. Check the position of the switches on the DIP for the serial (Host) port (if your unit has a Host port) against the addressing information in the “I/O Communication and Control”chapter.
9. Ensure that the interlock loop is closed both at the Contactor Interlock and at the User port. (See the description of the Contactor Interlock in the “Installation”chapter for more information.)
10. Ensure that input power meets specifications. (See the “Specifications” chapter for more information.)

Checks with the Unit Powered On

1. Check the unit’s input and remote power connections to ensure the proper power is being supplied to the unit.
2. Check the LEDs on all units to determine that the proper ones are lit.
3. Note any error code (that is, any “Exxx”number) displayed on the front panel or Pinnacle Remote Active Panel. See “Error Code Troubleshooting Table” later in this chapter for additional information.
4. Working with the passive front panel, ensure that the front panel LEDs POWER ON, INTERLOCK, OUTPUT, and SETPOINT LEDs are lit (see “Troubleshooting Table” in this chapter). Note which, if any, of these are not lit. If the INTERLOCK LED is not lit, error code E020, E022, or E023 should be displayed on the front panel. See “Error Code Troubleshooting Table” in this chapter for a suggested response to any of these errors.
5. Verify that LEDs light to show the control and regulation settings. Then verify that the OFF LED is lit.

6. If you suspect an LED is malfunctioning, cycle the Pinnacle Plus+ unit's power on and off. If the problem reoccurs, call AE Global Customer Support.
7. Working with the passive front panel, note whether the BUS FAULT or OVERTEMP LEDs on the front panel are illuminated (see “Error Code Troubleshooting Table” in this chapter). If the BUS FAULT LED is lit, error code E002 should be displayed on the panel. If the OVERTEMP LED is displayed, E004 should be displayed. Consult the error codes table in the following section for a suggested response to any of these errors. If no error code is displayed, cycle the Pinnacle Plus+ unit's power on and off to determine whether the LED is functioning properly.
8. Working with the Pinnacle Remote Active Panel, verify that the output display screen information is displayed (see the “Output Display Screen”section of the “Installation” chapter for details). If the display screen shows an error message, see “Error Code Troubleshooting Table” in this chapter. If the display remains blank, cycle the Pinnacle Plus+ unit's power on and off. If the problem re-occurs, call AE Global Customer Support.
9. Determine whether the cooling fans are functioning, and ensure your cabinet allows for adequate ventilation for all the units in the cabinet. (To determine the correct volumes, see the “Installation” chapter.) If the fans are not functioning properly, call AE Global Customer Support.
10. If the unit powers up well and communicates, you may restore the default settings of the unit through the Active or Remote Front Panel; you may also use the Host port.
11. Issuing command 0 through the serial communication (Host) port will turn the unit off.
12. If the pulsing switch is defective the unit will deliver current but not voltage.

Passive Front Panel Help Codes

When only a Passive Front Panel (PFP) is available, the Pinnacle Plus+ unit will display 4 character strings on start up to identify personality cards installed in the unit. A code will flash once for each card installed. The following table describes the strings.

Table 7-1. *Passive Front Panel Help Codes*

PFP Display String	Personality Card
P-0	No Cards
P-01 or P-17	Dual User Card
P-03 or P-26	PROFIBUS Card

Table 7-1. *Passive Front Panel Help Codes (Continued)*

PFP Display String	Personality Card
P-04	Host Protocol Translator Card
P-05 or P-21	Single User Card
P-18 or P-28	AE Bus Card
P-22 or P-29	Master/Slave Card with AE Bus
P-23 or P-30	DeviceNet Card
P-32	Master/Slave Card with PROFIBUS

Troubleshooting Table

Table 7-2. *Troubleshooting LEDs*

LED	On	Off	Status
POWER	X		Normal
POWER		X	The Pinnacle Plus+ unit is not receiving AC input power. Power the unit off. Using all applicable safety precautions, inspect your AC input power source to ensure that it is properly connected and that the specified voltage is being applied to the Pinnacle Plus+ unit. (See the "Specifications" chapter for AC input power specifications.) If the unit is damaged, the internal main fuses may be opened. *Note:* These fuses should only be accessed by AE personnel. See "AE Global Customer Support" on page 7-19 for information concerning the return of units for repair.
OUTPUT	X		Normal
OUTPUT		X	The Pinnacle Plus+ unit is not producing output. See "Checks if the Output Does Not Turn On."
SETPOINT	X		Normal
SETPOINT		X	The Pinnacle Plus+ unit is not operating within set point. Note the error code on the display and see "Error Code Troubleshooting Table" on page 7-13.

Table 7-2. *Troubleshooting LEDs (Continued)*

LED	On	Off	Status
INTERLOCK	X		Normal
INTERLOCK		X	An interlock fault condition exists. Note the error code on the display and see "Error Code Troubleshooting Table" on page 7-13.
BUS FAULT	X		A bus fault condition exists. Note the error code on the display and see "Error Code Troubleshooting Table" on page 7-13.
BUS FAULT		X	Normal
OVERTEMP	X		An over-temperature fault condition exists. Note the error code on the display and see "Error Code Troubleshooting Table" on page 7-13.
OVERTEMP		X	Normal
ARC	X		After the output shuts off, this LED lights momentarily to indicate that the hard arc count limit was reached during the previous run. However, if the arc count limit was set to zero, this LED lights for a predetermined time for every hard arc seen by the unit during the process run.
ARC		X	During an on cycle, this LED remains unlit normally. After the output shuts off, if this LED remains unlit, the hard arc limit was not reached during the previous run.

Checks if the Output Does Not Turn On

1. Verify that the joules mode is disabled or has a valid set point value. (For more information, read about the "Energy"function in the "I/O Communication and Control" chapter.)
2. Verify that the target life counter is disabled or has a valid value. (For more information, read about the "Target"function in the "I/O Communication and Control" chapter.)
3. For dual models, verify that both units are enabled. For more information, consult the descriptions for E020 in the table in the following section.
4. Verify that the user-definable power, voltage, and current limits are set to values reasonable for the process application.
5. Check for interlock, bus fault, or over-temperature faults.

6. From the front panel main menu press SUPPLY → DEFAULTS and reset the unit default settings. Or send command **119** through the Host port to reset all defaults.
7. Try again to turn on output power.

Help Code Troubleshooting Table

If the output does not turn on, your unit may display one of the following help codes.

Table 7-3. Help Code Troubleshooting Table

Help Code Number	Help Code Message	Problem Indicated	Suggested Action
H001	**Wrong Control Mode**	The action requested was not from the control source. For example, an AE Bus command was issued, but the unit is in Local control mode.	Check the control mode. Set it to the desired control source.
H002	**Can't Change While Output is On**	The action requested cannot be performed because the power supply output is on.	Turn off output power and try again.
	Output is Already On	You have attempted to turn on the output but output power is already on.	Remove power from the power supply, restart, and try again.

Table 7-3. Help Code Troubleshooting Table *(Continued)*

Help Code Number	Help Code Message	Problem Indicated	Suggested Action
H004	**User Limit Out of Range**	You have attempted to set a power, voltage or current limit to a value outside the allowable range.	Retry setting the limit using an acceptable value. See the "Specifications" chapter for more information.
	Timer Out of Range	You have attempted to set a timer to a value outside the allowable range.	Retry setting the timer using an acceptable value. See the "I/O Communication and Control" chapter for more information.
	Arc Count Limit Out of Range	You have attempted to set the arc count limit to a value outside the allowable range.	Retry setting the limit using an acceptable value. See the "I/O Communication and Control" chapter for more information.
	Arc Timer Out of Range	You have attempted to set the arc timer to a value outside its allowable range.	Retry setting the timer using an acceptable value. See the "I/O Communication and Control" chapter for more information.
	Arc Trip Level Out of Range	You have attempted to set a trip level to a value outside the allowable range.	Retry setting the trip level using an acceptable value. See the "I/O Communication and Control" chapter for more information.
	Frequency Out of Range	You have attempted to set frequency to a value outside the allowable range.	Retry setting the frequency using an acceptable value. See the "I/O Communication and Control" chapter for more information.
	Reverse Time Out of Range	You have attempted to set reverse time to a value outside the allowable range.	Retry setting the reverse time using an acceptable value. See the "I/O Communication and Control" chapter for more information.

Continued on next page

Table 7-3. Help Code Troubleshooting Table *(Continued)*

Help Code Number	Help Code Message	Problem Indicated	Suggested Action
H004 Continued from previous page	**Invalid Target Selection**	You have attempted to select a target that is not available.	Retry setting the target using an acceptable value. See the "I/O Communication and Control" chapter for more information.
	Target Life Out of Range	You have attempted to set target life to a value outside the allowable range.	Retry setting the target life using an acceptable value. See the command **12** in the "I/O Communication and Control" chapter for more information.
	Invalid Recipe Step	You have attempted to enter a recipe step that is invalid.	Retry setting the recipe step using an acceptable value. See the "I/O Communication and Control" chapter for more information.
Continued on next page	**Ramp Start Point Out of Range**	You have attempted to set a ramp start point to a value outside the allowable range.	Re-adjust the ramp start point by setting a smaller percentage. See the "Setting the Ramp" section in the "I/O Communication and Control" chapter for a description of the ramp option.

Table 7-3. Help Code Troubleshooting Table *(Continued)*

Help Code Number	Help Code Message	Problem Indicated	Suggested Action
H004 Continued from previous page	**Ramp Time Out of Range**	You have attempted to set ramp time to a value outside the allowable range.	Retry setting the ramp time using an acceptable value. See the "I/O Communication and Control" chapter for more information.
	Run Time Out of Range	You have attempted to set run time to a value outside the allowable range.	Retry setting the run time using an acceptable value. See the "I/O Communication and Control" chapter for more information.
	Joule Setpoint Out of Range	You have attempted to set the joule set point to a value outside the allowable range.	Retry setting the joule set point using an acceptable value. See the "I/O Communication and Control" chapter for more information.
	Joule Threshold Out of Range	You have attempted to set the joule threshold to a value outside the allowable range.	Retry setting the joule threshold using an acceptable value. See the "I/O Communication and Control" chapter for more information.
H005	**Invalid Control Mode**	You have attempted to set a control source other than Local, Host, or User.	Set the control source to Local, Host, or User.
	Invalid Regulation Mode	You have attempted to set the regulation mode to something other than power, current, or voltage. *Note:* Output power must be off (that is, output must be de-energized) to switch between regulation modes.	Set a valid mode for regulation (that is, power, current, or voltage). See the "I/O Communication and Control" chapter for more information.
	Invalid Parameter	You have attempted to set an operating parameter to a value outside its allowable range.	Set a valid value for the parameter. See the "I/O Communication and Control" chapter for more information.

Table 7-3. Help Code Troubleshooting Table *(Continued)*

Help Code Number	Help Code Message	Problem Indicated	Suggested Action
H006	**Analog Setpoint Selected**	You have attempted to change the regulation mode, or a set point, when the power supply has been set to respond to an external (analog) source.	De-assert the analog set point and retry the function. For more information see command **17** in the "I/O Communication and Control" chapter.
H007	**Faults Are Active**	You requested output On while fault was active.	Clear fault and try again.
H009	**Data Byte Count Incorrect**	The number of data bytes sent does not match the number of data bytes required by the command.	Check the command's requirements and resend the command. For more information see the "I/O Communication and Control" chapter.
H010	**User Port Has Priority**	After selecting a target other than 1 from the User port, you have attempted to select another target through another interface (that is, through either a serial port or a panel).	Use the User port to select the target. Or, to select the target through another interface, select target 1 from the User port. *Note:* When you have selected a target greater than 1 through the User port, the User port's target setting has priority.
H012	**Specified Interface Not Installed**	You have attempted switch to User control when your power supply model is not equipped with a User card.	Select another interface (Local or Host). For more information see the "I/O Communication and Control" chapter.
H016	**Reset Target Life**	Target life counter is enabled and has expired.	Reset the target life counter.

Table 7-3. Help Code Troubleshooting Table *(Continued)*

Help Code Number	Help Code Message	Problem Indicated	Suggested Action
H019	**Can't Change While Recipe is Active**	You have attempted to initiate a unit function that is not allowed while the power supply is executing a recipe.	Delay initiating the desired function until the recipe is complete. Or turn off output and disable the recipe function before attempting to initiate the desired function again. For more information, see the "I/O Communication and Control" chapter.
H021	**Joule Delivery Not Complete**	The joules delivered counter is enabled and running and you have attempted to turn off output power before the counter expired.	Delay initiating the desired function until the joule counter expires. Or turn disable joule mode and then shut off output power. For more information, see the "I/O Communication and Control" chapter.
H025	**Configured as a Slave Unit**	You have attempted to initiate a unit function that is not allowed while the power supply is configured as a slave.	De-assert the slave status of the unit and retry the function. For information regarding this procedure, see "Master/Slave Operation" in chapter 5 of this manual.
H026	**Can't Change: in Master/Slave System**	You have attempted to initiate a unit function that is not allowed while the power supply is configured in a master/slave system.	Disable the master/slave system and retry initiating the unit function. For more information on this procedure, see "Master/Slave Operation" in chapter 5 of this manual.
H028	**Setpoint Out of Range**	You have attempted to set a set point to a value outside the allowable range.	Retry setting the set point using an acceptable value. See the "I/O Communication and Control" chapter for more information.

Table 7-3. Help Code Troubleshooting Table *(Continued)*

Help Code Number	Help Code Message	Problem Indicated	Suggested Action
H031	**User Port Reset is Active**	The User port reset is asserted.	De-assert the User port reset function. See the "I/O Communication and Control" chapter for more information.
H099	**Command Not Implemented**	The Pinnacle Plus+ unit does not support the command most recently sent by the computer host.	Review the list of commands. For a list of commands, see the "I/O Communication and Control" chapter.

If by following the information in these checklists and this table, you fail to identify the problem, please call AE Global Customer Support. If the unit's front panel or Pinnacle Plus+ Remote Panel displays an error code, please consult the following error codes table for further troubleshooting ideas.

To re-set the unit's user-selectable parameters to the factory defaults, read about the default function in the "I/O Communication and Control" chapter.

Clearing the Error Code

Error codes ("Exxx" numbers) appear on the passive front panel, the remote passive panel, and the Pinnacle Remote Active Panel. These messages contain both the error code and a brief description of the problem. The following table explains more about error codes and messages and how to respond to them.

Error codes are typically generated by two types of faults: self-clearing or explicit clear. When the unit experiences a self-clearing fault condition, the unit turns off output and displays an error code on the panel. When the fault condition is no longer present in the system, the panel ceases to display the error code. (You then can turn on the output.)

When the unit experiences an explicit-clear fault condition, the unit turns off output and displays an error code. Once the fault condition is no longer in the system, you must acknowledge the condition from your controlling interface before turning on output.

To reset the Pinnacle Plus+ unit, do one of the following:

- From the front panel, press the OFF button to acknowledge the condition. Then press the ON button to turn on output.
- Through the DeviceNet interface, send the Poll Command message twice: once to turn off output and once to turn on output (see the description of Byte 4).

Error Code Troubleshooting Table

Table 7-4. *Error Code Troubleshooting Table*

Error Code Message	Problem Indicated	Suggested Action
E000 **DSP Init Control Fault**	The DSP failed to respond to the processor.	Power the unit off and then back on. If the error code reappears, contact AE Global Customer Support.
E001 **Out of Setpoint Timer Expired**	The out-of-set point timer has expired.	Increase the set point timer value or disable the timer by setting it equal to 0. If the problem persists, check your process parameters for limiting factors. That is, ensure that your load impedance matches the impedance of the Pinnacle Plus+ unit.
E002 **Bus Fault**	The DC bus has failed–probably due to an AC input power problem.	Using all applicable safety precautions, inspect your AC input power source to ensure that it is properly connected and that the specified voltage is being applied to the Pinnacle Plus+ unit. (See the “Specifications” chapter for AC input power specifications.)
E004 **Heat Sink Over-Temperature**	The unit is overheating.	Inspect the unit's cooling system and review cooling specifications: ensure that the input air temperature is correct, that the Pinnacle Plus+ unit's fans are functioning properly, and that your cabinet allows for adequate ventilation for all the units in the cabinet. For more information, see the “Installation” chapter.

Table 7-4. *Error Code Troubleshooting Table (Continued)*

Error Code Message	Problem Indicated	Suggested Action
E005 **Momentary Power Fluctuation**	The AC input power line dipped below required operating conditions. This condition may be due to an AC power black-out or brown-out.	Using all applicable safety precautions, inspect your AC input power source to ensure that it is properly connected and that the specified voltage is being applied to the Pinnacle Plus+ unit. (See the "Specifications" chapter for AC input power specifications.)
E006 **DSP Watch Dog Failure**	The DSP has failed.	Call AE Global Customer Support.
E007 **Initialization Fault**	There has been an initialization fault.	1. Remove all input power from the power supply and then restart the unit. 2. Reset all defaults, and then try step 1 above again. 3. If this fault persist call AE Global Customer Support.
E009 **Output Ground Fault Detected**	Output positive terminal is not PE grounded.	Connect output positive terminal to PE ground (available only on certain options).

Table 7-4. *Error Code Troubleshooting Table (Continued)*

Error Code Message	Problem Indicated	Suggested Action
E011 **Side A: Inverter Fault Occurred**	Unit A's power inverter cannot produce power.	Using all applicable safety precautions, inspect your AC input power source to ensure that it is properly connected and that the specified voltage is being applied to the Pinnacle Plus+ unit. Check the input power line voltage on all phases to ensure that it meets specifications (see the “Specifications” chapter). Run the power supply to a dummy load to determine if it will indeed produce voltage or current.
E012 **Side B: Inverter Fault Occurred**	Unit B’s power inverter cannot produce power.	Using all applicable safety precautions, inspect your AC input power source to ensure that it is properly connected and that the specified voltage is being applied to the Pinnacle Plus+ unit. Check the input power line voltage on all phases to ensure that it meets specifications (see the “Specifications” chapter). Run the power supply to a dummy load to determine if it will indeed produce voltage or current.
E020 **Interlock Open: User**	The system interlock on the unit's analog User port has not been satisfied.	Power off the Pinnacle Plus+ unit. Ensure that the interlock pin on the User port connector has been properly connected (see the “I/O Communication and Control” chapter). Ensure that all system interlocks have been satisfied. Power the unit back on.

Table 7-4. *Error Code Troubleshooting Table (Continued)*

Error Code Message	Problem Indicated	Suggested Action
E021 **Interlock Open: Cable**	The ribbon cable between the logic card and the inverter board has come loose.	Call AE Global Customer Support.
E022 **Interlock Open: Contactor**	The unit's Contactor Interlock has not been satisfied.	Power off the Pinnacle Plus+ unit. Ensure that the Contactor Interlock is properly connected. Ensure that all system interlocks have been satisfied. Power the unit back on. For more information about Contactor Interlock connector, see the "Installation" chapter.
E024 **Invalid Regulation Mode**	The User port regulation mode for has been set to an invalid value. *Note:* Output power must be off (that is, output must be de-energized) to switch between regulation modes.	Set the User port regulation mode to a valid value. (See "I/O Communication and Control" chapter for additional information.)
E033 **Message Queue Overflow**	The microprocessor has fallen behind and cannot keep up with events.	De-energize the Pinnacle Plus+ unit and then restart.
E051 **PROFIBUS Watch Dog Expired**	The PROFIBUS master stopped talking to the Pinnacle Plus+ supply after establishing communications.	Have the master reestablish communications and send a "master reset" to clear the Pinnacle Plus+ unit's display.
E054 **PROFIBUS MAC Reset or Offline**	The PROFIBUS interface has taken itself "off-line," probably in response to another error.	Cycle the Pinnacle Plus+ unit's power off and on and re-establish communications between the master and slave. If the error code reappears, call AE Global Customer Support.

Table 7-4. *Error Code Troubleshooting Table (Continued)*

Error Code Message	Problem Indicated	Suggested Action
E055 **PROFIBUS Command Buffer Overflow**	A PROFIBUS command arrived before the last sent command was executed and cleared from memory.	Slow down the PROFIBUS communication rate or the rate at which commands are sent. Make sure data consistency (module consistency) is enabled in the PROFIBUS master.
E059 **PROFIBUS Master Released Unit**	The PROFIBUS master has stopped communicating with the Pinnacle Plus+ unit using the proper protocol. This "slave" is now available to be "owned" by another master. If output is on, the Pinnacle Plus+ unit turns off and fails safe.	To recover from the "off state," have a PROFIBUS master establish communication with the Pinnacle Plus+ unit and send a "master reset" to clear the Pinnacle Plus+ unit's display.
E060 **AE Bus Command Buffer Overflow**	An AE Bus command arrived before the last sent command was executed and cleared from memory.	Slow down the AE Bus communication rate or the rate at which commands are sent.
E070 **Internal DeviceNet Communications Error**	An internal communications error has occurred on the DeviceNet card (Slot 0).	No suggested action.
E081 **Initializing Master Slave**	This error occurs at startup in units that are configured with a master/slave Host interface card. Once the master/slave Host card has been successfully initialized, the fault self-clears.	Ordinarily, if this fault does not clear automatically, there is a hardware problem. Check your master/slave cabling.
E086 **Overvoltage**	The unit was in an overvoltage condition for longer than was set on the overvoltage timer.	No suggested action.

Table 7-4. *Error Code Troubleshooting Table (Continued)*

Error Code Message	Problem Indicated	Suggested Action
E087 **Overcurrent**	The unit was in an overcurrent condition for longer than was set on the overcurrent timer.	No suggested action.
E088 **Short Circuit Condition**	One of the following short circuit conditions occurred: a shorted chamber, shorted cable, or a failed pulsing switch. The unit detects a short circuit if the following conditions exist: • the power, current, or voltage limit is active (or enabled) • the current is above the current threshold of pulsing • the unit detects a hard arc.	Cycle AC power to the unit.
E092 **No Master Detected**	No master system is detected. At least one unit must be set as the master unit.	Verify a unit is set as the master unit, or that the link to the master unit has not been broken.
E093 **Invalid Frequency**	An invalid frequency has been set to properly operate the unit.	Reset the frequency for the unit.
E095 **Reverse Time Limit Exceeded**	In a stand-alone dual unit, most likely you have set a higher voltage limit for the receiver side than for the transmitter side. The maximum reverse time is inversely proportioniate to the voltage limit.	Reduce the reverse time set for the transmitter side, or lower the voltage limit in the receiver side.

Table 7-4. *Error Code Troubleshooting Table (Continued)*

Error Code Message	Problem Indicated	Suggested Action
E182 **Master/Slave Fault**	A fault has occurred in the master/slave system.	Check your master/slave cabling. See the "I/O Communications and Control" chapter for more information.
E183 **No Master Detected**	No master system is detected. At least one unit must be set as the master unit.	Verify a unit is set as the master unit, or that the link to the master unit has not been broken.

AE GLOBAL CUSTOMER SUPPORT

Please contact one of the following offices if you have questions:

Table 7-5. *Global Customer Support Locations*

Office	Contact
AE, World Headquarters 1625 Sharp Point Drive Fort Collins, CO 80525 USA *Note:* For returns and repairs, please call Global Customer Support to get the correct shipping address.	Phone (24 hrs/day, 7 days/week): 800.446.9167 or 970.221.0108 Fax (M–F, 7:00 am – 5:30 pm MST): 970.407.5981 Email: technical.support@aei.com (We will respond to email by the next business day.) *Note:* For customers outside the US, please contact your local AE office.
AE, GmbH Raiffeisenstrasse 32 70794 Filderstadt (Bonlanden) Germany	Phone: 49.711.77927.0 Fax: 49.711.7778700
AE, Japan KK TOWA Edogawabashi, Bldg. 347 Yamabuki-cho, Shinjuku-ku Tokyo, 162-0801 Japan	Phone: 81.3.32351511 Fax: 81.3.32353580

Table 7-5. *Global Customer Support Locations (Continued)*

Office	Contact
AE, Korea Ltd. Gongduk Building, 4th floor 272-6 Seohyun-Dong, Bundang-Gu, Seongnam-Si Kyunggi, 463-050 Korea	Phone: 82.342.705.2100 Fax: 82.342.705.2766
AE, United Kingdom Unit 5, Minton Place, Market Court, Victoria Road Bicester, Oxon OX26 6QB UK	Phone: 44.1869.320022 Fax: 44.1869.325004
AE, Taiwan, Ltd. 10F-6, No. 110, Chung Shan Rd. Sec. 3, Chungho City, Taipei Hsien Taiwan 235	Phone: 886-2-82215599 Fax: 886-2-82215050
AE, China Rm. 910 Anhui Building, No. 6007 Shennan Road, Shenzhen, China 518040	Phone: 86-755-83867986 Fax: 86-755-83867984

RETURNING UNITS FOR REPAIR

Before returning any product for repair and/or adjustment, ***first follow all troubleshooting procedures***. If, after following these procedures, you still have a problem or if the procedure instructs you to, call AE Global Customer Support and discuss the problem with a representative. Be prepared to give the model number and serial number of the unit as well as the reason for the proposed return. This consultation call allows Global Customer Support to determine whether the problem can be corrected in the field or if the unit needs to be returned. Such technical consultation is always available at no charge.

If you return a unit without first getting authorization from Global Customer Support and that unit is found to be functional, you will be charged a re-test and calibration fee plus shipping charges.

To ensure years of dependable service, Advanced Energy® products are thoroughly tested and designed to be among the most reliable and highest quality systems available worldwide.

WARRANTY

Advanced Energy® (AE) products are warranted to be free from failures due to defects in material and workmanship for 12 months after they are shipped from the factory (please see "Warranty Statement" below, for details).

Note: If the product has a "Warranty Void if Seal is Broken" label, you must receive prior approval from AE before you can remove the power supply box cover. If you remove the box cover before receiving approval from AE, the product warranty is no longer valid. Contact AE Global Customer Support for more information (see "AE Global Customer Support" on page 7-19).

In order to claim shipping or handling damage, you must inspect the delivered goods and report such damage to AE within 30 days of your receipt of the goods. Please note that failing to report any damage within this period is the same as acknowledging that the goods were received undamaged.

For a warranty claim to be valid, it must:

- Be made within the applicable warranty period
- Include the product serial number and a full description of the circumstances giving rise to the claim
- Have been assigned a return material authorization number (see below) by AE Global Customer Support

All warranty work will be performed at an authorized AE service center (see list of contacts at the beginning of this chapter). You are responsible for obtaining authorization (see details below) to return any defective units, prepaying the freight costs, and ensuring that the units are returned to an authorized AE service center. AE will return the repaired unit (freight prepaid) to you by second-day air shipment (or ground carrier for local returns); repair parts and labor will be provided free of charge. Whoever ships the unit (either you or AE) is responsible for properly packaging and adequately insuring the unit.

Authorized Returns

Before returning any product for repair and/or adjustment, call AE Global Customer Support and discuss the problem with them. Be prepared to give them the model number and serial number of the unit as well as the reason for the proposed return. This consultation call will allow Global Customer Support to determine if the unit must actually be returned for the problem to be corrected. Such technical consultation is always available at no charge.

Units that are returned without authorization from AE Global Customer Support and that are found to be functional will not be covered under the warranty (see warranty statement, below). That is, you will have to pay a retest and calibration fee, and all shipping charges.

Warranty Statement

The seller makes no express or implied warranty that the goods are merchantable or fit for any particular purpose except as specifically stated in printed AE specifications. The sole responsibility of the Seller shall be that it will manufacture the goods in accordance with its published specifications and that the goods will be free from defects in material and workmanship. The seller's liability for breach of an expressed warranty shall exist only if the goods are installed, started in operation, and tested in conformity with the seller's published instructions. The seller expressly excludes any warranty whatsoever concerning goods that have been subject to misuse, negligence, or accident, or that have been altered or repaired by anyone other than the seller or the seller's duly authorized agent. This warranty is expressly made in lieu of any and all other warranties, express or implied, unless otherwise agreed to in writing. The warranty period is 12 months after the date the goods are shipped from AE. In all cases, the seller has sole responsibility for determining the cause and nature of the failure, and the seller's determination with regard thereto shall be final. The AE Warranty Statement may be superseded by a service agreement entered into between AE and the buyer.

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